ICT Infrastructure Project Opportunities in Mexico

A Resource Guide for U.S. Industry

USTDA

U.S. TRADE AND DEVELOPMENT AGENCY

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The U.S. Trade and Development Agency

The U.S. Trade and Development Agency helps companies create U.S. jobs through the export of U.S. goods and services for priority infrastructure projects in emerging economies. USTDA links U.S. businesses to export opportunities by funding project preparation and partnership building activities that develop sustainable infrastructure and foster economic growth in partner countries.

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1 Introduction

The U.S. Trade and Development Agency (USTDA) helps companies create U.S. jobs by exporting U.S. goods and services for priority development projects in emerging economies. USTDA links U.S. businesses to export opportunities by funding project preparation and partnership-building activities that develop sustainable infrastructure and foster economic growth in partner countries.

This Guide provides U.S. companies and exporters an overview of infrastructure projects across Mexico's information and communications sector, primarily over the next three years. The selected ICT project opportunities are profiled following. ICT Sector Overviews are provided in an Annex at the end of this Resource Guide.

When preparing this Guide, currency amounts are converted from local currencies to United States Dollars (USD) based on the current exchange rate. Due to fluctuations in currency values, accuracy levels for engineering and cost estimates for different projects, and various timing of cost information publication, this report's monetary values should be considered approximate. Unless explicitly indicated otherwise, all currency values are in United States Dollars (USD).

1.1 Regional ICT Development

From an ICT development perspective, Mexico:

- Exceeds the world average for the percentage of its population with internet access;
- Ranks 14th globally and second regionally in terms of total mobile telephone subscriptions; and
- Places slightly below the world average for broadband access.

Mexico's ICT industry hosts private enterprises. Subsea communication cable access is available on the west coast, both international and domestic. Developers are pursuing projects for subsea cable access on the east coast. Mexico also operates several telecommunications satellites.

The Latin American/Caribbean region, in total, represents approximately seven percent of the global ICT market and is generally growing faster than world averages. Brazil and Mexico are the two largest ICT country markets.

Mexico is a large importer of ICT goods and services, with ICT goods imports alone representing 15.8 percent of all imports. Therefore, current supply opportunities for U.S. ICT technology providers are attractive. Mexico also exports substantial amounts of ICT goods (14.8 percent of total exports in 2019), but little (less than one percent of total) in the way of ICT services.

The remainder of this Resource Guide defines specific sector opportunities relevant to U.S. exporters for Mexico.

1.2 Authors

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1.3 Acknowledgments

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2 MEXICO

2.1 ICT Demographics

Mexico has more than 9,330 kilometers (km) of coastline, spanning the Caribbean Sea, Gulf of Mexico, and the North Pacific Ocean. The country's topography varies widely from low coastal plains to desert, plateau, and rugged mountainous terrains. Thus, the country's landscape poses some challenges for ICT infrastructure development.

Mexico's landmass is just under two million square kilometers or slightly less than three times the size of Texas. Roughly 55 percent of its land is agricultural, with another third forested. Affecting ICT infrastructure, Mexico's central and southern portions are subject to volcanic eruptions and earthquakes. The Pacific coast is vulnerable to tsunamis, and the Gulf coast is subject to hurricanes.

Mexico is home to just over 130 million people. The majority of the population resides in the middle of the country between the states of Jalisco and Veracruz. Roughly 25 percent of the population lives in and near Mexico City. Over 81 percent of Mexico's citizenry is urban. Mexico City, the nation's capital (with a population of 22 million), is roughly four times bigger than the next largest municipality, Guadalajara. Six Mexican cities have populations greater than one million people.

2.2 ICT Sector Development

Mexico's existing ICT sector is reasonably well developed concerning fixed and mobile telephone access, internet use, and broadband access. The country has approximately 96 mobile cellular subscriptions per 100 inhabitants, ranking 14th globally in total subscriptions. Nearly 66 percent of the population had internet access by 2018.[1,2]

For U.S. companies offering software, hardware, or other products or services to operators, the main potential customers in the telecom market in Mexico are the following[3]:

- ***Fixed telephony*:** Nine providers, including Telmex, Movistar, Axtel, Izzi, Cablevision, Bestel, Megacable, Alestra, and TotalPlay.
- ***Mobile telephony*:** seven key wireless players, including Telcel, Movistar, AT&T, Maxcom, and Axtel. The two largest mobile virtual network operators (MVNOs) are Virgin Mobile and Megacel.
- ***Internet:*** 10 internet service providers - Infinitum (Telmex), Movistar, Maxcom, Axtel, Izzi, Cablevision, Bestel, Megacable, Alestra, and TotalPlay.
- ***Pay TV:*** several fixed providers also offer pay TV (Axtel, Izzi, Cablevision, Bestel, Megacable, Alestra, and TotalPlay), as do Dish and Maxcom.

[1] CIA World Factbook https://www.cia.gov/the-world-factbook/countries/mexico/#communications
[2] Index Mundi https://www.indexmundi.com/g/r.aspx?v=4010
[3] U.S. Commercial Service https://www.trade.gov/knowledge-product/mexico-t-telecommunications-equipment

- ***Telco-OTT Providers:*** "Over-The-Top" (OTT) providers deliver one or more services or types of content across an IP (internet protocol) network. Mexican OTT providers include Claro Video, Claro Musica, Blim, Spotify, Max Diversion, Axtel TV, Veo, Megacable Play, Netflix, Amazon Prime, Apple TV, and Totalmovie.

The technologies employed for connectivity are coaxial cable (39 percent), DSL (36 percent), fiber optic (24 percent), and satellite (0.1 percent). Telmex is the dominant player in fixed broadband with a 50 percent market share in terms of subscriptions compared to Televisa, Mega Cable, and Total Play at 24.3, 16, and eight percent, respectively. Mexico offers 2G, 3G, and 4G cellular services for mobile telephony, with carriers readying for 5G.

The country has two landing points (at Mazatlán and Tijuana) for the 10,000 km Pan American Crossing (PAC) subsea cable.[4] This cable links the United States, Mexico, Costa Rica, and Panama along the Pacific coast and offers onward connectivity to international cables. Mexico has fourteen satellites, of which half have service lives of ten years or fewer.[5]

2.3 Regulatory Landscape

As of 2014, the principal telecommunications regulator in Mexico is the Federal Telecommunications Institute. The Institute is an autonomous public agency with unique status and resources to regulate and promote competition and efficient development of the telecommunications and broadcasting sectors. Responsible for the regulation, promotion, and supervision of the use, enjoyment, and exploitation of the radio spectrum, orbital resources, satellite services, public telecommunication networks, and broadcasting and telecommunications services, the Institute has the authority to regulate access to active and passive infrastructure and other essential, related resources. The Federal Telecommunications Institute, which superseded the previous Federal Telecommunications Commission, is also the authority for antitrust matters in the broadcasting and telecommunications sectors.

Before 2013, the Televisa group had a virtual monopoly in Mexican TV broadcasting. Sector reforms allowed the creation of new broadcast television channels so that today, Mexico has 821 television stations, mostly privately owned. Foreign satellite and cable operator services are available. In 2016, Mexico was the first Latin American country to transition from analog to digital transmissions, allowing for better image and audio quality and a more comprehensive selection of programming from television networks. More than 1700 radio stations also serve the nation.

2.4 ICT Sectors Profiled

This Resource Guide reviews eleven Mexican development projects, spanning the following ICT sectors:

[4] Fiber Atlantic http://www.fiberatlantic.com/submarinecablemap/
[5] N2YO https://www.n2yo.com/satellites/?c=&t=country

- ***Terrestrial Telecommunications Network Infrastructure: Telephone, Internet, and Broadband*** - Mexico enjoys reasonable telephone and broadband access, although growth opportunities exist. Current focal areas for further enhancing service include the adoption of 5G and providing enhanced telecommunications capabilities to rural communities.
- ***Subsea Communications Networks*** - Mexico has access to one international subsea communications cable, landing on its Pacific coast and running from the United States to Panama. Also, the country has two domestic cables. At least three new, planned cables (one, GigNet-1, described following) will offer the country direct, east coast access to the United States, further expanding international connectivity.
- ***Data Centers and Cloud Computing*** - *Mexico* hosts numerous enterprise and co-location data centers. Growth in the segment is rapid. A profile of Querétaro's data center initiative follows.
- ***Smart Cities and e-Government*** - Although several Mexican municipalities have adopted a range of smart cities technologies, federal and local governments have planned additional projects. This Resource Guide describes three initiatives.
- ***Internet of Things (IoT) and Artificial Intelligence*** - ***Both*** strong government and private sector support for IoT and AI technologies exist in Mexico. This Guide features CEMEX's digital transformation initiative.

2.5 Projects Profiled

Profiles of eleven Mexican ICT projects follow, as listed in Table 1:

Table 1: ICT Development Projects - Mexico

Project	Sponsor
IFT Roadmap 2021-25	Instituto Federal de Telecomunicaciones (IFT)
Digital Transformation and Social Inclusion	Dirección General de Política de Telecomunicaciones y Radiodifusión (DGPTR)
Financing for Rural and Semi-urban Telecom SMEs	Organismo Promotor de Inversiones en Telecomunicaciones (PROMTEL)
National Digital Strategy/Internet for All	Coordinación de Estratégia Digital Nacional (CEDN)
Tabasco Telecommunications Master Plan	State Government of Tabasco
GigNet-1: Submarine Cable – Florida to Cancun	FB Submarine Partners LLC
Querétaro Digital Hub	Secretaría de Desarrollo Sostenible, Estado de Querétaro (SEDESU)
National Digital Identity System	Secretaría de Gobernación (SEGOB)
Modernization of Public Financial Management Systems	Secretaría de Hacienda y Crédito Público (SHCP)
Chetumal Free Trade Zone and Smart City	State Government of Quintana Roo
CEMEX Digital Transformation 4.0	CEMEX

IFT Roadmap 2021-25	
SUBSECTOR	**Terrestrial Communications Network Infrastructure: Telephone, Internet, and Broadband**
LOCATION	**Mexico**
PROJECT VALUE	**>$1 Billion Annually**

PROJECT SUMMARY

- Mexico's telecommunications regulator, the Federal Institute of Telecommunications (IFT), has adopted a 5-year strategy and roadmap to support the development of the country's digital ecosystem.
- The roadmap contains 13 strategies and 54 lines of regulatory action to support five main objectives:
  - Promote the development and efficient use of networks and infrastructure;
  - Promote fair competition for the telecommunications and broadcasting sectors;
  - Promote the adoption of new technologies in the digital ecosystem;
  - Ensure service quality and the rights of digital services users; and
  - Strengthen IFT's institutional innovation.

PROJECT BACKGROUND AND DESCRIPTION

The Federal Institute of Telecommunications (IFT[6]) is an autonomous entity that regulates the telecommunications and broadcasting (T&B) sectors. IFT's mission includes the efficient development of the T&B system for the benefit of society by:

- Regulating and supervising the use of radio spectrum, infrastructure, and networks used to provide T&B services;
- Monitoring and ensuring economic competition in the T&B sector; and
- Promoting access to T&B technologies and services.

In December 2020, IFT published a strategy and roadmap to guide its regulatory efforts from 2021 to 2025. The roadmap considers the rapidly evolving T&B sectors and associated innovative regulatory mechanisms.

The roadmap focuses on the "digital ecosystem," recognizing the ever-changing business models and possibilities within the T&B sectors. The digital ecosystem is the set of operators, suppliers, markets, infrastructure, and other tools (applications, platforms, networks, access devices, et al.) that intervene in the different links of the value chain to provide services and digital content on

[6] IFT – Instituto Federal de Telecomunicaciones

telecommunications and broadcasting networks, including the Internet. Regulatory consideration of the entire digital ecosystem reflects a paradigm shift within the sector.

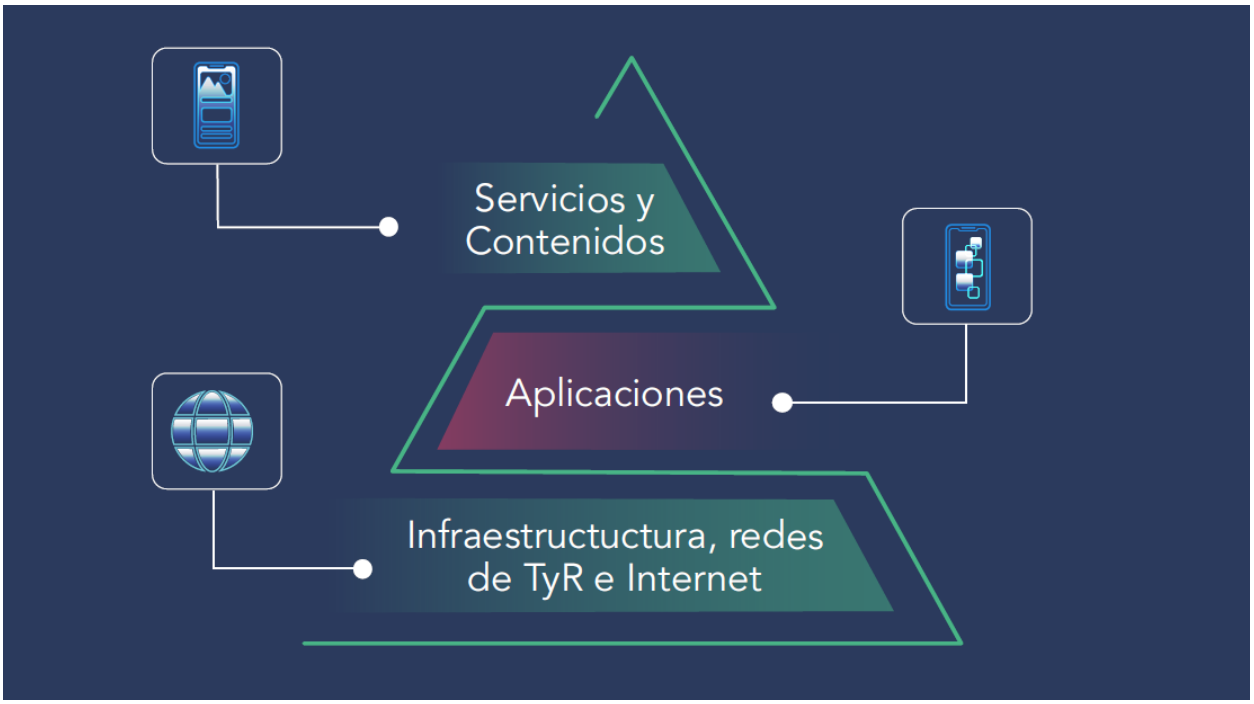
Historically, traditional telecommunication service providers supplied end services to users (e.g., voice calls, text messages, or broadcast television services) under a vertically-integrated business model through their own applications and infrastructure. With the development of the World Wide Web, new entrants were able to provide specific applications or services through the Internet over the infrastructure of the incumbent service providers. As multiple mobile operators started to roll out new networks simultaneously, new business opportunities arose, such as tower companies.

Wholesale markets have created additional opportunities for new entrants, for example, mobile operators who do not own infrastructure providing telecommunications services using others' assets (Mobile Virtual Operators). Many of the actors who originally entered the sector as specialized, niche players have expanded vertically into new value chain layers, such as software providers expanding into data centers or providing voice and messaging services.

As a result of rapid and dramatic industry structural changes, the IFT has concluded the paradigm shift means that the regulator cannot understand the T&B sectors, much less regulate them, in an isolated way. Instead, IFT must address the industry from an integrated perspective of the digital ecosystem.

From a conceptual point of view, the digital ecosystem comprises three fundamental layers, infrastructure and internet networks, applications, and services and content, as shown in Figure 1.

Figure 1: Graphical Model of the Digital Ecosystem



More specifically, the digital ecosystem layers include:

- ***Infrastructure and Networks*** -- including the interconnected telecommunications networks that make up the Internet (the base layer):
  - Providers of telecommunications and broadcasting networks and equipment (including Internet connectivity providers);
  - Passive infrastructure providers, such as towers, fiber optic networks, among others;
  - Hardware providers for network users and servers;
  - Data center service providers and cloud computing infrastructure; and
  - Network security companies.

- ***Applications*** -- (the middle layer) using the infrastructure layer to enable the provision of services and content in the upper layer, including:
  - Application providers for e-commerce;
  - Application providers for the provision of OTT (Over the Top) services, including digital platforms;
  - Multimedia application providers;
  - Software providers for the development of applications or search engines;
  - Providers of databases and tools for online use; and
  - Hosting and support service providers.

- ***Services and Contents***: (the upper layer) spanning free and restricted television services, fixed and mobile telephony and Internet access, and OTT services, including:
  - Voice calls, video calls, and messaging;
  - Dedicated communications for enterprises;
  - Online markets and office programs;
  - Search engines and social networks;
  - Videos, television programs, series, and movies;
  - Music; and
  - Video games.

IFT has organized the regulatory roadmap around five objectives supporting 13 critical strategies:

Objective 1: Promote the deployment, development, and efficient use of networks and infrastructure that facilitate the development of the digital ecosystem and foster digital inclusion:

- *Strategy 1.1*: Facilitate and create favorable conditions for the investment, deployment, development, and extension of network and infrastructure coverage for the T&B (especially fiber-optics, 4G, and 5G) sector.
- *Strategy 1.2:* For the development of the digital ecosystem, promote the efficient use of T&B networks, infrastructure, and other services using available network infrastructure;
- *Strategy 1.3:* Efficiently manage and leverage the radio spectrum. Monitor, verify, and evaluate the proper use thereof.
- *Strategy 1.4:* Contribute to universal access of T&B capabilities under reasonable conditions and social equity.

Objective 2: Promote economic and free competition in the sectors of T&B in the context of the digital ecosystem:

- *Strategy 2.1*: Foster effective competition through the monitoring and analysis of the markets of the T&B sector in the context of the digital ecosystem, considering the new technologies and new business models that correspond to the scope of competence of the Institute.

Objective 3: Promote the development of the digital ecosystem and the adoption of new technologies and digital use cases (e.g., IoT, 5G technology, Big Data, AI, Blockchain, et al.):

- Strategy 3.1: Promote security, trust, and innovation to develop the digital ecosystem.
- Strategy 3.2: Foster the adoption of new technologies and digital use cases in society.

Objective 4: Ensure the quality, diversity, and plurality of the services of T&B and strengthen the rights of users and audiences in the digital ecosystem:

- *Strategy 4.1*: Ensure T&B sector services are provided under appropriate quality conditions for the promotion of the digital ecosystem;
- *Strategy 4.2*: Facilitate the development of an open and neutral Internet promoting competition and innovation in the digital ecosystem;
- *Strategy 4.3*: Promote diversity, plurality, and innovation in the T&B sector across the digital ecosystem; and
- *Strategy 4.4*: Strengthen the rights of users and audiences concerning the services of T&B in the digital ecosystem.

Horizontal Objective: Strengthen institutional innovation for enabling the development of the T&B sector and the digital ecosystem:

- *Strategy H.1*: Ensure internal efficiency in the development of the regulatory and competition functions of the Institute;
- *Strategy H.2*: Promote transparency and the protection of personal data in the processes, procedures, and activities of the Institute; and
- *Strategy H.3*: Promote coordination of the Institute with other national and international institutions to develop the T&B sector and the digital ecosystem.

IFT has further parsed the 13 strategies above into 54 lines of regulatory action for implementation from 2021 to 2025. While not all of these lines of regulatory action will spur investment in the T&B sector, some will foster investment and new business models, including:

- *1.1.1:* Collaborate with the different levels of government involved to standardize, simplify, harmonize, make transparent and streamline the processing and granting of permits for the deployment of infrastructure of T&B;
- *1.1.2:* Promote a regulatory framework that encourages the development of joint investment plans between T&B service concessionaires and other relevant entities for the installation and deployment of new T&B networks and infrastructure;
- *1.1.3:* Encourage investments in networks and infrastructure of relevant entities of the digital ecosystem that allow the development of new services, applications, and business models;

- *1.2.4:* Collaborate with other authorities to make infrastructure information available and inform them of rights of way for the orderly and efficient deployment of networks and infrastructure of T&B;
- *1.3.3*: Evaluate measures that optimize the availability of radio spectrum for innovative, experimental, and social uses (among the measures referred to are sandboxes/vertical licensing, private networks, usage by social and indigenous communities, et al.).
- *1.4.1*: Collaborate with the relevant institutions to design appropriate mechanisms to close the universal access gap.
- *2.1.4:* Ensure continuous monitoring of the regulatory measures imposed by the Institute, including those relating to the provision of digital services on the Internet. Adapt the metrics using a "smart regulation" criterion to ensure the effectiveness and successful evolution of the T&B sector and digital ecosystem.
- *3.1.1:* Develop and disseminate recommendations, guidelines, technical provisions, and good practices in the field of cybersecurity.
- *3.2.3:* Promote regulatory development in the productive sectors and society at large. Apply business models associated with new technologies related directly to the T&B sectors.
- *H.1.6:* Review existing regulations, the overall regulatory framework, and other provisions to align them with international best practices, an agile and flexible approach (soft law), and using the general principles of good regulation to respond to technological and digital ecosystem developments.

Investment-interested industry participants likely will most closely follow the 5G auction to be carried out under the roadmap. IFT expects additional investment opportunities for new technologies (IoT, Big Data, AI, Blockchain, et al.) and cybersecurity solutions and services.

PROJECT STATUS AND IMPLEMENTATION TIMELINE

IFT published a draft roadmap for public comment in August 2020. The regulator adopted and published its final strategy and roadmap in December 2020. The roadmap does not include detailed implementation timelines for the various elements. IFT has delegated these to annual work plans for the Institute.

Concerning the 5G auction, the IFT announced the creation of a 5G technical advisory committee on October 7, 2021. This mechanism allows interaction between the Institute, industry, academia, public entities, and any other interested party to expose the needs, strategies, perspectives, and studies of current and future 5G.

The technical advisory committee will establish six working groups:

- Timely allocation of spectrum for 5G;
- Deployment and availability of infrastructure for 5G;
- Applications and services linked to 5G (use cases and technological innovation);
- Regulatory aspects for 5G;
- Cybersecurity; and

- Experimentation and testing with 5G.

Industry observers suggest an approximate timeframe of 2023 for the 5G auction.

PROJECT COST AND FINANCING

IFT has not prepared a cost estimate for implementing the 5-year roadmap. Industry observers value the 5G auction alone as worth billions of dollars. Therefore, we estimate the cost to exceed $1 billion annually. Private sector participants in the digital ecosystem will be responsible for arranging their own implementation financing.

U.S. EXPORT OPPORTUNITIES

U.S. companies will likely participate directly in the 5G auction. Additional export opportunities for U.S. companies in conjunction with Mexico's 5G auction will include:

- Fiber optic network-backhaul hardware, software, and installation and maintenance services;
- Small- and pico-cell low-power base station hardware, software, and installation and maintenance services;
- Multiple-input/multiple-output (MIMO) technology, antenna modules, and installation, maintenance, and advisory services;
- Beamforming technology and advisory services;
- Centralized radio access network (C-RAN) technology, baseband unit hardware and software, and advisory services;
- Giga-bit WiFi technology, hardware, software, and advisory services; and
- Open-RAN compatible technology.

Additional 5-year roadmap implementation, U.S. export opportunities will likely include:

- Emerging technology solutions:
  - IoT;
  - Big Data solutions;
  - AI;
  - Blockchain;
- Cybersecurity solutions; and
- Advisory services.

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Digital Transformation and Social Inclusion	
SUBSECTOR	**Terrestrial Communications Network Infrastructure: Telephone, Internet, and Broadband**
LOCATION	**Mexico**
PROJECT VALUE	**$120 Million**

PROJECT SUMMARY

- Access to telecommunications and broadcasting is a right guaranteed by the State in Mexico.
- Recent estimates suggest over 70 percent of the Mexican population uses the Internet.
- Nevertheless, 11 percent, predominantly in rural areas, have no mobile coverage access.
- Mexico has established a program with an overarching objective to increase citizen access to the Internet through digital transformation and inclusion.
- This project comprises three components:
  - Telecommunications infrastructure: investment in critical, high-performance networks;
  - Digital inclusion; and
  - The development of digital infrastructure solutions.
- The Inter-American Development Bank (IADB) is financing the project through a $120 million loan.

PROJECT BACKGROUND AND DESCRIPTION

Mexico introduced regulatory changes to its telecommunications sector in 2013, including establishing an independent entity to regulate and promote competition and oversee the utilization of telecommunications and broadcasting. Significant results since June 2013 (through September 2019) include:

- Telecommunications sector growth of 88 percent, compared to 12.1 percent for the balance of the economy;
- Mobile phone service price reductions of 44 percent; and
- Increased mobile Internet subscriptions by nearly 200 percent.

Still, only about 70 percent of the population uses the Internet. Eleven percent, predominantly in the country's rural areas, have no access to mobile telephone coverage.

The Mexican government has made digital transformation a priority as a lever for social development. Access to telecommunications and broadcasting, including broadband and Internet, is a right guaranteed by the country. In addition, Mexico ensures the population's integration into

the knowledge and information society through its universal digital inclusion policy. The National Development Plan 2019-2024 positions the country's digital transformation as a priority.

The overall objective of this project is to increase citizens' access to the Internet through digital transformation and inclusion, supporting social development. The project aims to promote:

- Telecommunications infrastructure in critical, high-performance networks;
- Digital inclusion through the development of digital capacity and skills, especially in remote and marginalized areas; and
- Institutional strengthening in support of digital transformation and inclusion.

The project comprises three components divided into 13 subparts:

Component 1: Telecommunications Infrastructure - Investment in Critical, High-Performance Networks

- Ensure active infrastructure consisting of the design, architecture, and technical specifications for the backbone network and prioritize sites to which higher education institutions (public universities), research centers, specialty hospitals, and mission-critical sites will connect.
- Ensure active and passive infrastructure for deploying the high-performance backbone network to connect Mexico's National Research and Education Network (RNEI) and mission-critical sites. The country intends to develop a high-performance, mission-critical network to connect higher education institutions, research centers, specialty hospitals, and other mission-critical locations. Based on the design proposal for the backbone network, the country will develop active and passive infrastructure that can connect at least 1,300 sites to a virtual private network.
- Design, develop, and implement the active infrastructure necessary to connect priority public sites.
- Design and implement policy actions for modernizing the sector.

Component 2. Digital Inclusion

- Create Digital Inclusion Centers (CIDs). CIDs are public spaces open to the population in every federal entity in Mexico. These centers will aim to build digital skills in the community using technology tools and human resources to promote social inclusion. Highly- and very-highly-marginalized areas will host the CIDs. Component 2 supports investment in modernizing and renovating the CIDs and their technologies, including connecting the centers via a private virtual network integrated with the backbone.
- Provide Digital Inclusion Modules. Digital Inclusion Modules will be set up, via the necessary infrastructure, in public spaces operated by public agencies throughout the country.
- Develop a Certification Platform. The project will create a platform for issuing official certificates of achievement for skills taught in some of the CID courses.
- Support an Online Learning Platform. Develop a platform for students to obtain courses and materials offered at the CIDs through digital inclusion modules.

Component 3. Development of Digital Infrastructure Solutions

- Create a National Observatory of Technology Trends in Information and Communication Technologies. The observatory will reside within the Secretariat of Communications and Transportation (SCT) with its own physical infrastructure to identify, based on the degree of digital maturity, actions to promote the social and economic development of the country.
- Provide active infrastructure for the aggregation and publication of information in the communications sector. This infrastructure will consolidate data from the communications sector generated by various actors to monitor public and private policies and projects based on open-source data,
- Develop a comprehensive strategic planning and monitoring platform.
- Ensure sustainability and create a supporting action plan.
- Create a communication and governance model.

PROJECT STATUS AND IMPLEMENTATION TIMELINE

IADB approved the loan for project implementation on September 23, 2020. Table. 2 describes expected annual disbursements.

Table 2: Annual Project Disbursements

Year	Annual, $ Million	Cumulative, $ Million
1	8.5	8.5
2	28.4	36.9
3	27.9	64.8
4	27.6	92.4
5	27.6	120.0

PROJECT COST AND FINANCING

IADB has provided a $120 million loan to finance the project. Most of the budget is for ICT expenses under subcomponents 1.2, 2.1, and 1.2, as described in Table 3.

Table 3: Project Budget by Component

Project Component	Cost, $ Million
Component 1: Telecommunications Infrastructure: Investment in Critical, High-Performance Networks	**55.2**
1.1: Active infrastructure consisting of the design, architecture, and technical specifications for the backbone network and site prioritization	0.176
1.2: Active and passive infrastructure for the deployment of the high-performance backbone network to connect the RNEI and mission-critical sites	54.016
1.3: Design, development, and implementation of active infrastructure for prioritizing connected public sites and sites to be connected	0.265
1.4: Design and implementation of policy actions for modernizing the sector	0.742
Component 2: Digital Inclusion	**43.2**
2.1: Digital inclusion centers	39.877
2.2: Digital inclusion modules	1.418
2.3: Certification platform	0.484
2.4: Online learning platform	1.419
Component 3: Development of digital infrastructure solutions	**21.6**
3.1: National Observatory of Technology Trends in Information and Communication Technologies	5.409
3.2: Active infrastructure for the aggregation and publication of information in the communications sector	15.088
3.3: Comprehensive strategic planning and monitoring platform	0.801
3.4: Sustainability action plan	0.150
3.5: Communication and governance model	0.150
Total	**120.0**

U.S. EXPORT OPPORTUNITIES

Export opportunities for U.S. firms include:

- Hardware and connectivity for the 32 CIDs (one in each Mexican state);
- Software as a Service (SaaS) for information on the telecommunications sector and the National Observatory of Technology Trends;
- Advisory services:
  - Design, development, and implementation of solutions;
  - Cybersecurity strategy;
  - Sustainability action plan; and
  - Communication and governance model.

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Financing for Rural and Semi-Urban Telecom SMEs	
SUBSECTOR	**Terrestrial Communications Network Infrastructure: Telephone, Internet, and Broadband**
LOCATION	**Mexico (Rural Zones)**
PROJECT VALUE	**$30 Million**

PROJECT SUMMARY

- Organismo Promotor de Inversiones en Telecomunicaciones (PROMTEL) is the entity that promotes telecommunications investment under the Mexican Secretary of Communication and Transportation.
- In 2015, PROMTEL launched Red Compartida (Shared Network), the largest telecommunications project in Mexico's history. The project will expand 4.5G coverage to 92.2 percent of the country's population by 2024.
- PROMTEL began piloting rural and semi-urban initiatives in 2018 to reduce the digital divide further.
- Based on this experience, in 2020, PROMTEL established a collaboration agreement with the rural development fund, Fondo de Capitalización e Inversión del Sector Rural (FOCIR). The working arrangements focus on financing small and medium telecommunications enterprises with projects in priority and rural areas of the country. The projects include social components.

PROJECT BACKGROUND AND DESCRIPTION

Organismo Promotor de Inversiones en Telecomunicaciones (PROMTEL) promotes telecommunications investment under the Secretary of Communication and Transportation. PROMTEL operates along three lines:

- ***Infrastructure Development***: promoting the use of State assets and seeking to eliminate barriers to the deployment of telecommunications infrastructure.
- ***Investment Promotion***: fostering strategic actions to ensure project implementations spanning the development, investment, and deployment of telecommunications infrastructure.
- ***Red Compartida (Shared Network)***: managing the largest telecommunications project in the history of Mexico, a modern cellular network with 4.5G technology. Red Compartida's mission is to provide Internet and telephony services with higher quality and lower prices to boost competition and coverage in areas lacking access.

Red Compartida is a wholesale network under which other companies market Internet and telephone services to the population. It operates under a public-private partnership (PPP) scheme:

- PROMTEL provides the use of the frequency band of the radio spectrum, manages the contract, and supervises the network installation;
- Telecomm (Telecomunicaciones de México) provides access to an optical-fiber backbone; and
- Altán Redes, the private sector partner, provides financing for the development of the network. Further, the company oversees the design, installation, roll-out, operations, and network updates.

Mexico launched Red Compartida in 2015 with a request for expressions of interest and published the PPP tender in January 2016. PROMTEL selected Altán as the private sector partner at the end of 2016.

One of the PPP's goals is to ensure 92.2 percent of the population will have broadband access by January 2024. Another goal is to reach 111 Pueblos Mágicos (Magic Towns, as designated by the Secretary of Tourism[7]) by 2023. Table 4 describes the intermediate goals for Red Compartida.

Table 4: Annual Targets for Red Compartida

Year	Population Covered (%)	Pueblos Mágicos Reach (#)
2018	30%	28
2020	50%	56
2022	72%	83
2023	85%	111
2024	92.2%	111

In 2020, PROMTEL certified that Red Compartida had reached 50.2. percent of the population and 57 Pueblos Mágicos, exceeding the targets established for the PPP.

Even though Red Compartida is the largest telecommunications project in Mexico's history, it will not reach all rural and semi-urban populations. Therefore, in 2018, PROMTEL started to pilot alternative schemes. Pilots to date, serving as compelling case studies, include:

- Installing satellite connectivity in the areas of Hidalgo Joshil, San Jerónimo Tulijá, and Yajalón in the state of Chiapas to:
    - Provide financial services favoring financial inclusion;
    - Promote the use of the Internet by rural communities in the region; and
    - Allow the population to move towards digital inclusion and social and economic development.

[7] As of December 2020, the Secretary of Tourism has designated 132 Magic Towns throughout Mexico. All Magic Towns have important cultural and historical values. The Secretary of Tourism supports Magic Towns as alternative tourist destinations for national and foreign visitors.

- Constructing a 15km fiber-optic backbone with a 5km distribution line to deploy FTTH (fiber to the house) capability. As a result, providing Internet and 4.5G cellular telephone service in Cuauchichinola (Mazatepec) and Cuautitla (Tetecala) in Morelos state.
- Installing WiFi hotspots in Huayacocotla, Veracruz, with satellite connections and a business model under which users can acquire pre-paid data packets.

Building on these pilots, PROMTEL and FOCIR (which is attached to the Ministry of Finance and Public Credit and operates with the collaboration of the Ministry of Economy) signed a collaboration agreement in September 2020. The agreement establishes the basis for both parties to analyze telecommunications infrastructure investment projects proposed by small and medium telecommunications enterprises (SMEs). Ideally, proposed projects are located in priority and rural areas of the country and include a social commitment to serve schools, hospitals, libraries, and civic squares.

By September 2021, the collaboration had granted funding to 13 rural and semi-urban telecommunications projects. Figure 2 describes the geographic coverage of these projects.

Figure 2: Geographic Coverage of Financing Scheme for Telecommunication SMEs

This financing scheme observes the guidelines of the National Development Plan 2019-2024 and the Sectoral Plan for Communications and Transport 2020-2024. Access to financing follows a 10-step process:

- Establish contact with the PROMTEL team;
- Present the project proposal to PROMTEL;

- PROMTEL provides initial feedback on viability and bankability;
- Update the project proposal based on PROMTEL's feedback;
- PROMTEL verifies the project proposal;
- Present the verified project proposal to FOCIR with PROMTEL support;
- FOCIR provides initial feedback on bankability and financing considerations;
- PROMTEL provides a non-binding opinion on project viability;
- FOCIR issues the financing decision with proposed terms; and
- The parties sign the financing agreement.

Financing terms under this scheme are:

- Amounts up to 10 million pesos (approximately $500,000),
- Interest rate: fixed at 10 percent plus the value-added tax, and
- Maximum term of 40 months with a six-month grace period.

Access to the financing scheme is also subject to additional criteria, including credit history and guarantees.

PROJECT STATUS AND IMPLEMENTATION TIMELINE

PROMTEL and FOCIR signed their collaboration agreement in September 2020. During the first year, and despite the global pandemic, the collaboration approved 13 rural and semi-urban telecommunication projects for financing.

Each project financed under the scheme has a unique implementation timeline. PROMTEL requires a five-year projection of project cash flows. Its example cash flow analysis contemplates that all investment occurs during the first year.

PROJECT COST AND FINANCING

The total cost of the rural and semi-urban telecommunications projects will depend on the proposals submitted by SMEs and approved by PROMTEL and FOCIR. Since FOCIR operates as a development bank, the financing scheme is not subject to a pre-specified limit. We observe that the historical project approval rate was approximately one each month during the first year of the collaboration. At this rate, through 2024, the financing scheme could provide about $30 million for such Projects.

U.S. EXPORT OPPORTUNITIES

Rural and semi-urban network roll-outs offer several export opportunities for U.S. companies, including:

- Antennae systems, hardware, and software;

- Gateway earth stations;
- Fiber-optic network hardware and spares;
- Network and location system hardware and software;
- Small- and pico-cell technologies and equipment;
- Wireless telecommunications equipment;
- Information technology (IT) laboratory equipment;
- Batteries/battery storage solutions;
- Renewable ICT technologies, including photovoltaics; and
- Advisory services.

CONTACTS

Project Sponsor	U.S. Trade and Development Agency	U.S. Commercial Service
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National Digital Strategy - Internet for All	
SUBSECTOR	**Terrestrial Communications Network Infrastructure: Telephone, Internet, and Broadband**
LOCATION	**Mexico**
PROJECT VALUE	**$550 Million**

PROJECT SUMMARY

- In August 2021, Mexico adopted a National Digital Strategy with two key policies:
  - Digital Policy for the Federal Government – to transform public administration through the use of ICT; and
  - Social Digital Policy – to increase Internet coverage throughout the country.
- Comisión Federal de Electricidad (CFE), via CFE Telecomunicaciones Internet para Todos (CFE TEIT), is implementing the largest strategic action item, Internet para Todos (Internet for All). Key goals of the 2020-2024 business plan 2020-2024 include:
  - Establishing 200,000 free Internet connection points;
  - Serving 130,000 localities; and
  - Deploying a budget of 11 billion pesos (approximately $550 million).

PROJECT BACKGROUND AND DESCRIPTION

Mexico's National Digital Strategy (NDS) views ICT access and use as a tool for government and society to enhance relationships, activities, and production, thereby increasing the general welfare. Thus, one of the priority projects outlined in the National Development Plan 2019-2024 is Internet coverage for the whole of Mexico:

> *"Through the installation of wireless Internet throughout the country, the entire population will be offered connectivity on roads, public squares, health centers, hospitals, schools, and community spaces. It will be fundamental to combat marginalization and poverty and integrate depressed areas into productive activities."*

Five principles underpin the NDS:

- ***Austerity***: A principle of the common good, relating to achieving high-quality services with the maximum use of resources and reduction of expenditure;
- ***Combating Corruption***: To end unjust, unfair, and perverse practices that benefit particular interests by harming the State or its members;
- ***Efficiency in Digital Processes***: To achieve operational simplification and focused attention from government procedures;

- ***Information Security***: To ensure the stability, protection, and certainty of the information generated or safeguarded in digital systems or platforms. These assets should also provide strength and operational confidence; and
- ***Technological Sovereignty***: To create unique attribution of the nation to make decisions without external interference concerning policies and strategies within the digital and technological spheres.

Two separate policy areas frame the NDS:

- ***Digital Policy for the Federal Government*** – transforming public administration through the use of ICT to improve efficiency and transparency in the provision of government services to citizens; and
- ***Social Digital Policy*** – adding Internet coverage throughout the country to combat marginalization and connect the poorest and most remote areas, facilitating their integration into productive activities.

The Digital Policy for the Federal Government has six objectives:

- Improve and harmonize the regulatory framework of the federal government's digital policy through a comprehensive and simplified development of technological guidelines for the country to achieve technical and economic efficiency;
- Standardize ICT purchases through transparent, austere, and practical actions that generate savings and maximize the responsible use of public resources;
- Promote technological autonomy and independence to establish the leadership of the State in the definition of its Information and Communication Technologies;
- Obtain the maximum use of computer applications and infrastructure through the exchange of information and technological collaboration among Institutions;
- Promote a culture of information security that generates certainty and confidence to users of institutional and government technological services; and
- Promote the continuity and improvement of projects and programs based on integrating structured information available in the Institutions.

These objectives will serve as drivers for public sector ICT investment over the period 2021 to 2024, noting:

- Objective 2 will guide Federal government investments in hardware, software, and platform solutions;
- Objective 4 will generate a host of new e-Government applications and hence investment opportunities, including applying Advanced Electronic Signature technology; and
- Objective 5 will create a demand for cybersecurity solutions throughout the Federal government.

The six objectives of the Digital Policy for the Federal Government collectively contain 29 specific action items. The Social Digital Policy, the focus of this project, has three goals and thirteen action items:

1. Promote the integration and lighting of fiber optics systems owned by public bodies to transport signals and reduce the country's digital divide.
    - Direct collaborative actions with the Federal Electricity Commission (CFE) subsidiary, CFE Telecomunicaciones Internet para Todos.
    - Encourage optimizing the use of institutional communications networks and services to expand government capacities and coverage.
    - Promote the interconnection of the federal government.
    - Promote free Internet connectivity in public squares, health centers, hospitals, schools, and community spaces.

2. Promote the deployment of the Internet to all areas without coverage to achieve universal Internet coverage to the population.
    - Coordinate agreements and promote actions on connectivity with the private sector and communities in the country.
    - Promote private sector participation to cover last-mile deployment.
    - Coordinate collaboration mechanisms to promote the use of the Shared Network.
    - Promote coordination actions with local governments for the use of ICT infrastructure.
    - Promote the interconnection of federal government institutions through the National Fiber Optic Network and its extensions.

3. Improve the quality of social programs through technological solutions that facilitate and accompany actions aimed at the population's well-being.
    - Promote the development and implementation of technological mechanisms that favor transparency and monitoring in allocating public resources granted through Social Programs for Welfare.
    - Coordinate actions to improve information management.
    - Promote the use of ICT infrastructure to provide government services in forgotten areas.
    - From the technological point of view, provide support and guidance for defining and implementing priority welfare programs and projects.

The most prominent element of the Social Digital Policy is CFE Telecomunicaciones' Internet para Todos (CFE TEIT, or CEF Internet for All). CFE TEIT will invest 11 billion pesos (approximately $550 million) in extending Internet access in Mexico between 2020 and 2024. The entity will install WIFI hot spots in highways, parks, health care centers, schools, and community spaces and create 200,000 free Internet access points by 2025. The project will provide Internet access in approximately 130,000 locations.

PROJECT STATUS AND IMPLEMENTATION TIMELINE

Mexico's National Digital Strategy was adopted on August 15, 2021, and published in the Official Document on September 6, 2021. CFE TEIT approved its 2020-2024 business plan on December 16, 2020. Notable figures from the business plan are the 11 billion pesos investment and 200,000 free Internet access points by 2025.

The Annual Operational Work Program of CFE TEIT for 2021 calls for developing several projects in support of the deployment of the public telecommunications network:

- Develop a system to manage the services of the public telecommunications network, comprising two foci: one for the administration of fixed internet service (advance of 80 percent) and another for the administration of mobile telephony services (advance of 30 percent);
- Create a map for the services deployed by CFE-TEIT;
- Install 4G-LTE cell phone antennae with a configuration for rural areas to provide connectivity to 7.8 percent of the localities without access to the Shared Network;
- Install approximately 3,000 kilometers of last-mile fiber optics to bring connectivity to public places; and
- Install microwave radio links and satellite links.

CFE TEIT will publish further details in future annual work programs.

PROJECT COST AND FINANCING

The five-year budget for CFE-TEIT Internet for All project is 11 billion pesos (approximately $550 million).

Additional components of the NDS will have individual budgets, though the Federal Government has not yet published most.

U.S. EXPORT OPPORTUNITIES

The Internet for All network roll-out to remote areas will create several opportunities for U.S. companies, including:

- Antennae systems, hardware, and software;
- Gateway earth stations;
- Fiber optic network hardware and spares;
- Network and location system hardware and software;
- Small- and pico-cell technologies and equipment;
- Wireless telecommunications equipment;
- Information technology (IT) laboratory equipment;
- Batteries/battery storage solutions;
- Renewable ICT technologies, including photovoltaics; and
- Advisory services.

Further export opportunities for the NDS may include:

- Hardware:
  - Data center componentry (servers, racks, power, HVAC, site security, et al.); and
  - Digital operations center equipment (networking hardware, fiber optic cabling, components, power management hardware, et al.)
- Software:
  - Access to Software as a Service (SaaS) and related, scalable programs;
  - Custom software/applications for e-Government; and
  - Cybersecurity solutions.
- Advisory services:
  - e-Government design and development services and consulting;
  - Networking design, implementation, and security; and
  - Application design, development, testing, and implementation.

CONTACTS

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Tabasco Telecommunications Master Plan	
SUBSECTOR	**Terrestrial Communications Network Infrastructure: Telephone, Internet, and Broadband**
LOCATION	**Mexico (State of Tabasco)**
PROJECT VALUE	**$7 million**

PROJECT SUMMARY

- To address its digital gap, the State of Tabasco is preparing a Telecommunications Master Plan focusing on three areas:
  - Telecommunications infrastructure;
  - Fiber-optic infrastructure; and
  - The overall ICT ecosystem.
- Approximately 120 to 150 million pesos ($7 million) in public sector seed capital is required to implement the Master Plan.

PROJECT BACKGROUND AND DESCRIPTION

Red Compartida (Shared Network) is the largest telecommunications project in Mexico's history. The project will expand 4.5G coverage to 92.2 percent of the country's population by 2024. National coverage (by population) presently stands at 69 percent[8]. However, coverage in Mexico's five southern states is lower than the national average, at an aggregate of 58 percent, as shown in Table 5. Of these states, Tabasco has the most urgent need for improved coverage.

Table 5: Coverage of Red Compartida in Southern Mexico

State	Population	Population Served	Coverage
Tabasco	2,238,603	789,456	35%
Chiapas	4,796,580	2,362,277	49%
Campeche	822,283	564,257	69%
Quintana Roo	1,325,438	1,080,432	82%
Yucatan	1,955,577	1,649,976	84%
Total Region	***11,138,481***	***6,446,398***	***58%***

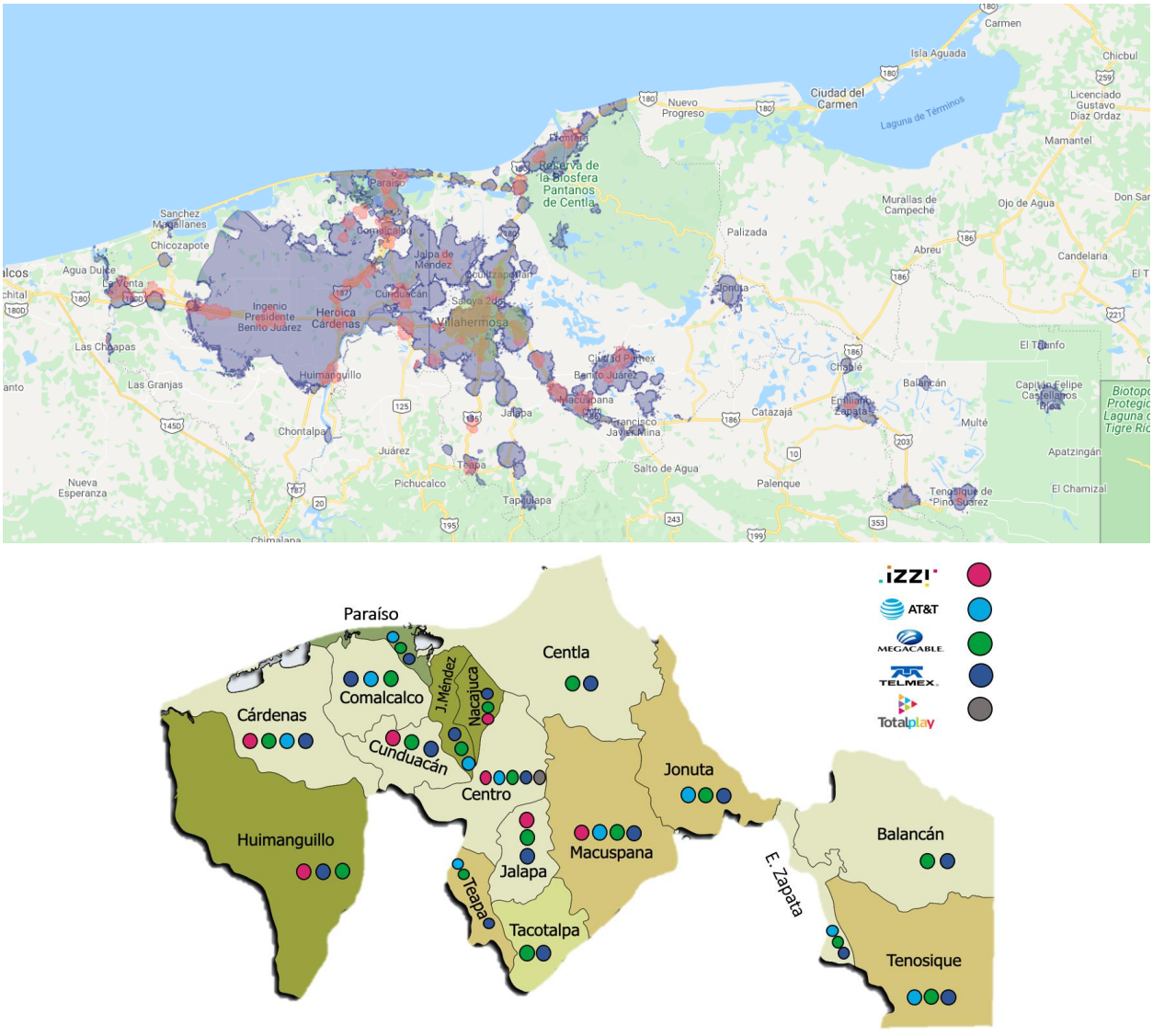
[8] https://www.redcompartida.igg.unam.mx/geoportal/dashboardPromtelPublic as of Dec 9, 2021

The State of Tabasco, with current Red Compartida coverage of 35 percent, falls above only two Mexican states nationally, Tlaxcala and Tamaulipas, at 33 and 34 percent, respectively. To address its digital gap, the State of Tabasco, through the Secretariat for Economic Development and Competitiveness, is preparing a Telecommunications Master Plan contemplating three key areas:

- Telecommunications infrastructure;
- Fiber-optic infrastructure; and
- The overall ICT ecosystem.

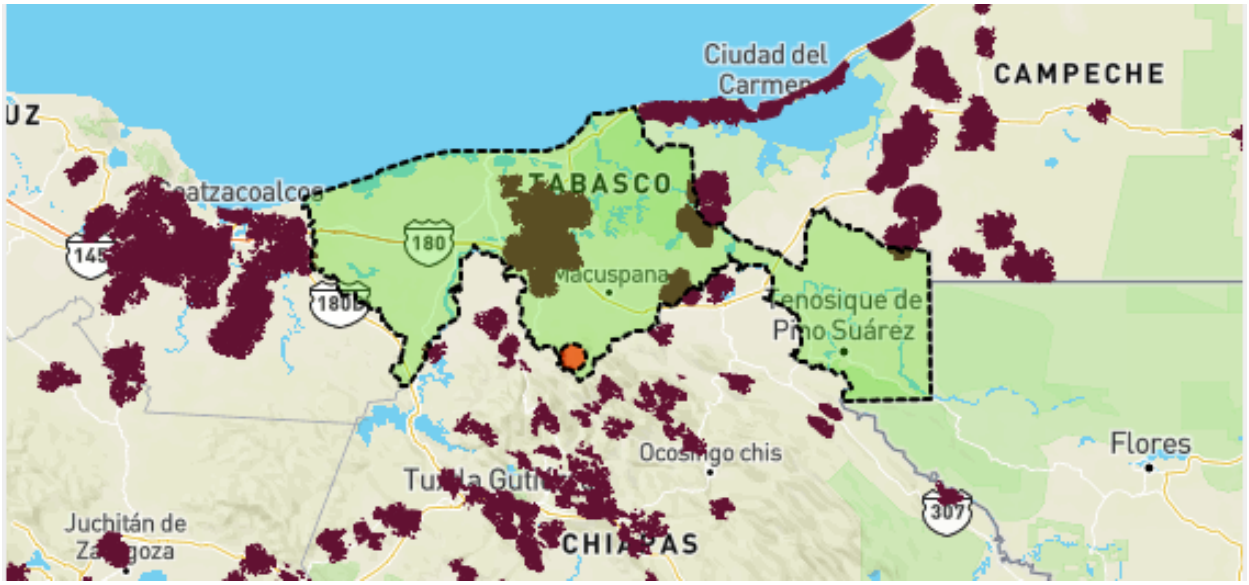
Guaranteed 4G service within the State of Tabasco is currently limited, as shown in Figure 3.

Figure 3: Guaranteed 4G Service by Commercial Providers in Tabasco



Red Compartida will increase coverage across Tabasco, but the program currently focuses on the central portion of the state, as denoted in brown in Figure 4. The state Master Plan aims to provide 4G or 4.5G coverage to underserved rural communities throughout the entire state.

Figure 4: Existing 4.5G Coverage by Red Compartida (denoted in red)



The second key area of the Master Plan is developing a solid fiber-optic backbone across the state. Private operators have made some advances in the Chontalpa area and the state's center. Other projects in development include the municipalities of Villahermosa, Paraíso, Jalpa de Méndez, Nacajuca, Cárdenas, Huimanguillo, and Teapa. There is also a fiber development project to span Paraíso to Frontera, which currently reaches Vicente Guerrero.

Much of the new backbone will take advantage of existing rights of way, as depicted in Figure 5, and include the following:

- The rail line from Chontalpa to Dos Bocas (shown in red);
- Southeast rail line from Coatzacoalcos to Palenque (in orange);
- PEMEX oil pipeline to Guadalajara (in green); and
- The oil pipeline between Cactus and Los Ramones (in yellow).

The fiber-optic backbone will also take advantage of the right of way of the Tren Maya, a megaproject under development and construction that will connect the five states of Southern Mexico through a new 1,500 km passenger and freight rail network. The first stage of the Tren Maya is a 278 km segment from Palenque (Chiapas) to Escárcega (Campeche), traversing the eastern part of Tabasco. The Master Plan contemplates a fiber-optic line from Tenosique to El Triunfo along this right of way.

Figure 5: Existing Rights of Way for Fiber-Optic Backbone

The fiber-optic backbone will also use rights of way along federal and state highways.

The third element of the Master Plan is the state's ICT ecosystem. The ecosystem will be cultivated by four institutions, one existing and three under development:

- ***CLEMA (Consortium for Applied Research, Innovation, and Training of High-Level Human Resources in Logistics and Distribution, Energy, and Advanced Manufacturing):*** CLEMA is a consortium of applied research centers to develop the productive sectors of the state of Tabasco. The Consortium is located in the municipality of Cunduacán, within the Tabasco Business Center Industrial Park, on an area of 16,951 m^2. CLEMA has a technological infrastructure that includes robotic applications and simulator intelligence.

- ***Analysis Laboratory for the Agro-Industrial and Food Sector***: The entity will be the first agri-food innovation laboratory in southeastern Mexico. Services will include shelf-life studies, sensory evaluation, and training for the sizable universe of local food industry producers, processing companies, and entrepreneurs. Tabasco expects the laboratory to be operational in June 2022.

- ***Laboratory for the Development of Artificial Intelligence***: This laboratory aims to define education for the future to support Industry 5.0-level initiatives. The state hopes to close the technological gap versus other countries using AI, mind-expertise, IoT, and cybersecurity. Client companies will have an AI-focused organization to support new

technology development and implementation, process automation, cost reduction efforts across production, logistics, and sales. The AI laboratory will operate by January 2023.

- ***DIGIFAB MACUSPANA*** – This Digital Manufacturing Laboratory will provide a space to bring the local industry together with equipment, techniques, and digital manufacturing processes. DIGIFAB MACUSPANA will focus on 3D printing, manufacturing, technology design, technology assembly, and consulting. The state plans for the laboratory to be operational in June 2022.

PROJECT STATUS AND IMPLEMENTATION TIMELINE

The Tabasco Telecommunications Master Plan is currently under development and will include an implementation plan and timeline. Preliminary indications suggest that the telecommunications infrastructure and fiber-optic backbone implementation will begin during the second half of 2022.

PROJECT COST AND FINANCING

USTDA is financing the Master Plan with a grant. The preliminary implementation budget for public sector seed capital is approximately 120 to 150 million pesos (about $7 million). The Master Plan will provide a more detailed budget estimate, including the required private sector investment.

The State Secretariat of Economic Development and Competitiveness will seek financing from national and international sources. The Secretariat expects implementation to include a private sector partner, either under concession or through a PPP.

U.S. EXPORT OPPORTUNITIES

The network roll-out to remote areas offers several opportunities for U.S. companies, including:

- Antennae systems, hardware, and software;
- Gateway earth stations;
- Fiber optic network hardware and spares;
- Network and location system hardware and software;
- Small- and pico-cell technologies and equipment;
- Wireless telecommunications equipment;
- Renewable ICT technologies, including photovoltaics and battery storage solutions; and
- Advisory services.

Additional support for the State´s ICT ecosystem development may include:

- Data center componentry (servers, racks, power, HVAC, site security, et al.);
- Cybersecurity solutions and services; and
- Emerging technology solutions such as IoT, AI, and 3D printing.

CONTACTS

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GigNet-1	
SUBSECTOR	**Subsea Communications Infrastructure**
LOCATION	**Mexico (Cancun Landing)**
PROJECT VALUE	**$38 Million**

PROJECT SUMMARY

- GigNet-1 is a 1,104 km subsea fiber-optic cable project that will connect Boca Raton, Florida, to Cancun, Mexico.
- GigNet, the owner and operator of an extensive broadband network in the Mexican Caribbean, will serve as the anchor customer of GigNet-1.
- Developed initially by FB Submarine Partners LLC, GigNet has announced its intent to acquire the project.
- Xtera and IT Telecom International are key implementation partners.
- In May 2021, GigNet announced the completion of the marine survey for GigNet-1.
- The project's planned ready-for-service date is the fourth quarter of 2022.

PROJECT BACKGROUND AND DESCRIPTION

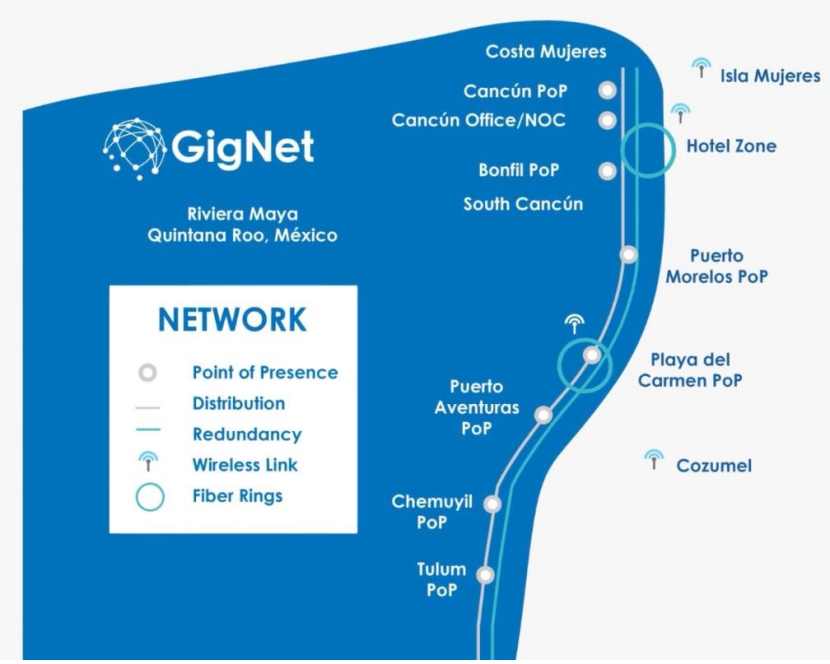
Mexico ranks seventh in the UN World Tourism Organization ranking of top tourist destinations. Mexico is the only Latin American and Caribbean country listed in the global top ten, receiving 45 million visitors in 2019, up nine percent from 2018.

The Mexican Caribbean is a star tourist destination in Latin America. The area's renowned combination of white-sand beaches, deep blue ocean waters, hundreds of historical sites with pyramids, and world-class cuisine entice travelers across the globe. The Cancun International Airport served 25 million passengers transiting through its facilities in 2019.

As Cancun re-opened its doors to travelers following the COVID-19 global pandemic, flights at the Cancun International Airport increased from an average of 39 flights per day in 2020 to 470 flights per day in 2021. International flights to Cancun are available from 42 cities in the United States and numerous cities throughout Europe and Latin America. Many cruise ship lines also call on nearby Playa del Carmen.

GigNet, a digital infrastructure company, has an extensive regional fiber-optic broadband network from Costa Mujeres, north of Cancun, through the Hotel Zone of Tulum. GigNet offers high-speed broadband solutions to enterprise, hospitality, and residential customers throughout the region. Figure 6 details GigNet's network in the State of Quintana Roo.

Figure 6: GigNet Network in the Mexican Caribbean (State of Quintana Roo)



GigNet-1 will be the first new fiber-optic cable in over 20 years specifically designed to meet the fast-growing demand for broadband capacity in the Mexican Caribbean. Key characteristics of the project are:

- Length: 1,104 km;
- Planned Capacity: 2 fiber pairs - 24 Tbps;
- Landing Points: Boca Raton, Florida and Cancun, Mexico; and
- Branch. Connection: planned and designed for the Dominican Republic.

Figure 7 maps the cable route planned for GigNet-1.

IT Telecom International's cable ship, the IT Intrepid, shown in Figure 8, will lay the cable. The IT Intrepid is a fully-furnished cable ship capable of installation and maintenance at all ocean depths. The vessel includes the IT ROVJET 207, a remotely operated vehicle for cable work and inspection to depths of 2,600 m.

Figure 7: GigNet-1 Planned Route

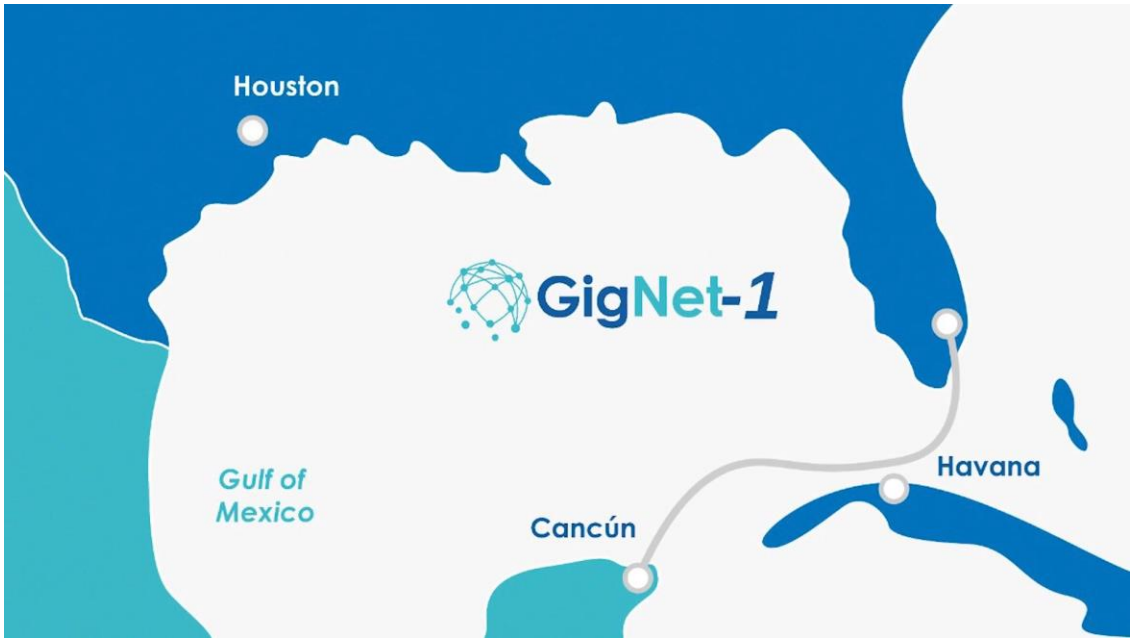


Figure 8: IT Intrepid Cable Ship

Xtera, Inc., a provider of innovative subsea fiber optic solutions, is the engineering, procurement, and construction (EPC) contractor for project implementation. Xtera will manage the overall project and provide the subsea wet-plant consisting of cable, repeaters, and submarine line terminals in Florida and Mexico. In cooperation with Xtera, IT International Telecom will perform the marine installation.

PROJECT STATUS AND IMPLEMENTATION TIMELINE

GigNet announced the completion of the marine route survey in May 2021. The survey included geotechnical, geophysical, and shipwreck assessments to develop a route optimized for cable

protection, avoidance of obstructions, and other factors critical for the project's successful installation.

An assessment of required data capacity (terabytes) is under review to inform the final route for cable installation. Permitting in both Florida and Mexico is also underway. GigNet expects the project to be ready for service during the fourth quarter of 2022.

PROJECT COST AND FINANCING

The project will require an investment of approximately $38 million. GigNet will arrange the financing. Funding sources typically used for subsea fiber-optic cable projects include strategic and governmental funds, U.S. and foreign banks, and family offices.

U.S. EXPORT OPPORTUNITIES

Export opportunities for U.S. firms include:

- Fiber optic cabling hardware and network-management hardware and software;
- Network modeling, design, and engineering services;
- Ship services/oversight;
- Installation/testing services/oversight; and
- Other technical and management advisory services.

In addition, once operational, GigNet will create new opportunities for over-the-top (OTT) telecommunications service providers.

CONTACTS

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Querétaro Digital Hub	
SUBSECTOR	**Data Centers and Cloud Computing**
LOCATION	**Mexico (Querétaro)**
PROJECT VALUE	**$400 Million**

PROJECT SUMMARY

- The ICT sector currently represents nearly 8 percent of Querétaro's economy.
- Several factors contribute to local sector growth:
  - An attractive location for data centers;
  - The successful collaboration of entities in a triple helix framework: higher education institutions and their research centers, productive sectors and their industry clusters, and regional government entities;
  - Digital transformation of other critical sectors in the region, particularly automotive and aerospace; and
  - Focused funding initiatives to foster further innovation.
- Querétaro is fostering the development of several new data centers to continue to enhance its position as a digital hub.

PROJECT BACKGROUND AND DESCRIPTION

Querétaro's traditional industrial base of automotive and aerospace industry suppliers grew substantially under NAFTA. The digital transformation within these industries spurred ICT sector activities within the state. Now, Querétaro is becoming a regional digital hub in its own right.

Data Centers

Cushman and Wakefield's 2021 Data Center Global Market Report includes Querétaro for the first time. In the report, Querétaro is listed with 52MW of active data center development, placing it ahead of other listed sites such as Shanghai, NYC-Northern NJ, Berlin, Madrid, and Los Angeles. São Paolo is the only other Latin American city referenced.

Physical and infrastructure conditions in Querétaro are attractive for locating data centers. For example, Even Group already has 3,000 km of fiber optic network connecting 10 Mexican cities. The company is constructing a long-distance network from Laredo, TX, through Monterrey, Querétaro, and eventually reaching Mexico City. Four other networks also serve Querétaro.

Querétaro is close to major Mexican markets, including Mexico City, Monterrey, and El Bajío. Developers indicate that Querétaro has proximity to the capital city without inherent risks, such as earthquakes.

Equinix currently operates two data centers in Querétaro, offering 4,000 m^2 colocation space. The centers have 2N UPS redundancy (i.e., fully redundant, mirrored, independent, uninterruptible power supplies) and N+2 cooling redundancy (i.e., two back-ups). The Equinix facilities are carrier-neutral with multiple diverse fiber entry points. Five network service providers currently operate within each data center.

Ascenty, a joint venture between Digital Realty and Brookfield, is constructing two data centers in Querétaro:

- ***Mexico 1***: 21 MW total power, 20,000 m^2 total area, and 2,700 racks, located in Querétaro Industrial Park; and
- ***Mexico 2***: 31 MW total power, 24,000 m^2 total area, and 3,400 racks, located at Arkansas State University's Querétaro Campus.

Both Ascenty data centers will be carrier-neutral and have three separate power connections, in addition to on-site diesel generator sets, with designs are certified to Tier III. Investment in both data centers is reportedly $300 million. Figure 9 shows artists' renderings of both Ascenty data centers. Table 6 describes data center capabilities by tier.

Figure 9: Mexico 1 and 2 Data Centers

Table 6: Data Center Capabilities by Tier[9]

Tier	User Group	Uptime (%)	Annual Downtime (hours)	Power Outage Protection (hours)
1	Small Businesses	99.671	28.8	No redundancy
2	Medium-size Businesses	99.749	22.0	Partial redundancy
3	Large Businesses	99.962	1.6	72
4	Enterprise Corporations	99.995	0.4	96

[9] ComRent/The Aberdeen Group

The Brazilian firm OData has also announced a data center in Querétaro with a total investment of $100 million:

- The first phase - 4 MW and 8,260 m^2;
- Total plan - 32 MW and 52,350 m^2.

Implementation of the Triple Helix Framework
Under Querétaro's State Development Plan, the state administration has worked intensively to consolidate a Triple Helix model, creating links among educational institutions, government authorities, and local industry. The state government has worked with industry clusters and chamber organizations to detect specific industrial and business needs. Concurrently, local academic institutions have focused on human capital development and market requirements.

During the 2020-21 school year, registered enrolment in undergraduate programs throughout Querétaro was 84,379 students in 771 programs with 9,040 teachers. Additionally, there are 6,723 students in superior university technician programs and 5,838 in postgraduate courses, or a total of nearly 100,000 students in local higher education. Major regional universities include:

- Autonomous University of Querétaro (UAQ);
- Technological University of Querétaro (UTEQ);
- Technological University of San Juan del Río (UTSJR);
- Aeronautical University in Querétaro (UNAQ);
- Technological University of Corregidora (UTC);
- Polytechnic University of Querétaro; and
- Polytechnic University of Santa Rosa Jáuregui (UPSRJ).

Querétaro is home to 54 research and technological development centers in which 3,524 researchers participate. UAQ alone hosts 14 schools and departments that develop lines of research, accommodating nearly 500 researchers.

Key industrial clusters in Querétaro include:

- ***Vortice IT, the ICT cluster***, located in its own industrial park - the cluster indicates that the state's ICT sector has over 300 companies generating over 20,000 direct jobs;
- ***The Automotive Cluster of Querétaro*** - representing a sector of over 300 companies contributing over 68,000 direct jobs;
- ***Querétaro's Aerocluster*** - for the aeronautical sector of over 80 companies generating approximately 12,000 direct jobs; and
- ***Plastics Cluster*** - representing a sector with over 600 micro-, small, and medium plastics enterprises and about 12,000 direct jobs.

State Program for Technology Development and Innovation

In 2020, taking advantage of the Triple Helix framework, the State of Querétaro introduced Programa Estatal para el Desarrollo de Tecnología e Innovación (PEDETI), a program for technology development and innovation launched by Secretaría de Desarrollo Sostenible (SEDESU). The program was updated in 2021 and currently supports six important industry 4.0 projects:

Regional Productivity Center 4.0 (Ceprodi[10] 4.0) - seeking to promote Industry 4.0 in the plastics, automotive, aerospace, and metalworking sectors by adopting best practices and providing management training in big data, rapid prototyping, and Industry 4.0. Mabe, General Electric, the Plastics, Automotive, Aeroclusters, and various research centers participate in the council of this center.

3D Printing Consortium (ConMad)[11]- a regional industry center for 3D printing in different metals and Mexico's only one of its kind. ConMad is a project between the Center for Engineering and Industrial Development (Cidesi), General Electric (GE), the Center for Advanced Technology, the Center for Research and Advanced Studies (CINVESTAV) of the National Polytechnic Institute, and the government of Querétaro through SEDESU.

Nanosatellite K'OTO - the satellite will take images of the national territory, contributing to the technological sovereignty of the country's space sector. The National Laboratory of Space and Automotive Engineering at the National Autonomous University of Mexico in Querétaro manages the project. This nanosatellite will feature folding panels, whose total dimension is 10 x 10 x 10 centimeters, weighing 1.3 kilograms. The satellite will undergo various stress tests, condition reviews, and space certification before its launch.

Laboratory of Quantum Technologies for Communications (LaTeC2[12]) – focused on four principal axes of research and development in disruptive technologies for the advanced communications of this laboratory, including:

- Atomic clocks;
- Optical frequency combs;
- Quantum gravimeters; and
- Quantum cryptography.

Metra Center - located at the Polytechnic University of Santa Rosa Jáuregui. The center focuses on metrology to strengthen the state automotive and aerospace sectors. The center includes an industrial warehouse and laboratories of dimensional, optical, and electrical metrology, in addition to thermometry, prototyping, impulsion systems, and an innovation room.

Embedded Software Lab – a facility including four interactive dashboards to research industry 4.0 ICT technologies. The dashboards support Industry 4.0 devices, electronic

[10] Ceprodi – Centro Regional de Productividad
[11] ConMad - Consorcio de Manufactura Aditiva
[12] LaTeC2 – Laboratorio de Técnicas Cuánticas para las Comunicaciones

tests for industrial IoT applications, and testing of sensors and actuators, and embedded software and components.

PROJECT STATUS AND IMPLEMENTATION TIMELINE

The phased build-out of each data center has a unique implementation timeline. Equinix's data centers have been operational since February 2021. The other data centers are in the permitting and construction phases.

SEDESU launched PEDETI in February 2020 and updated the program in February 2021. Each PEDETI-financed program has a distinct implementation timeline.

PROJECT COST AND FINANCING

Announced investment in data centers in Querétaro exceeds $400 million. Each operator is arranging appropriate financing.

Continued funding of PEDETI initiatives will depend on future state government budgets.

U.S. EXPORT OPPORTUNITIES

U.S. export opportunities for Querétaro's digital hub include:

- Data center componentry:
  - Servers;
  - Racks;
  - Power solutions;
  - HVAC; and
  - Site security;
- Fiber optic network-backhaul hardware, software, and installation and maintenance services;
- IT laboratory equipment;
- Emerging technology solutions for Industry 4.0:
  - Internet of Things;
  - Robotics;
  - 3D printing;
  - Nanosatellite solutions; and
  - AI.

CONTACTS

Project Sponsor	U.S. Trade and Development Agency	U.S. Commercial Service
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National Digital Identity System	
SUBSECTOR	**Smart Cities and e-Government**
LOCATION	**Mexico**
PROJECT VALUE	**$225 Million**

PROJECT SUMMARY

- The Mexican Constitution establishes identity as a fundamental human right to access economic opportunities and improve wellbeing.
- Civil registries are managed by each of the country's 32 states and coordinated by a federal agency.
- The project aims to strengthen Mexico´s ID system to ensure a unique identity for all Mexicans and foreign residents, facilitating ID verification and authentication for services and benefits.
- The project comprises three components:
  - Improving the quality and coverage of civil registration services;
  - Designing and implementing the foundational system and verification services; and
  - Institutional strengthening and project management.

PROJECT BACKGROUND AND DESCRIPTION

Identification (ID) systems are critical to enabling access to public and private services for vulnerable populations. The National Development Plan 2019-2024 includes developing a universal and reliable digital ID system to facilitate enhanced access to health, education, social protection, and financial services for the Mexican population.

The constitutional reform of 2014 introduced identity as a basic human right enabling individuals to exercise a range of civil, economic, and social rights. This right is considered universal for the entire population in the country, regardless of nationality or legal migratory status, and for Mexican citizens residing abroad. The identity right is critical to enable access to economic opportunities and improve individuals' welfare, including direct payments from social programs and access to education and employment. The absence of a national ID system has historically hampered the effective exercise of this constitutional right.

The 1974 General Population Law assigned the mandate to register and certify the identity of all residents of Mexico to the Ministry of Interior through the National Population Registry (RENAPO[13]), working with civil registries managed by each of Mexico's 32 states. Under the decentralized federal framework, state-managed civil registries are responsible for registering

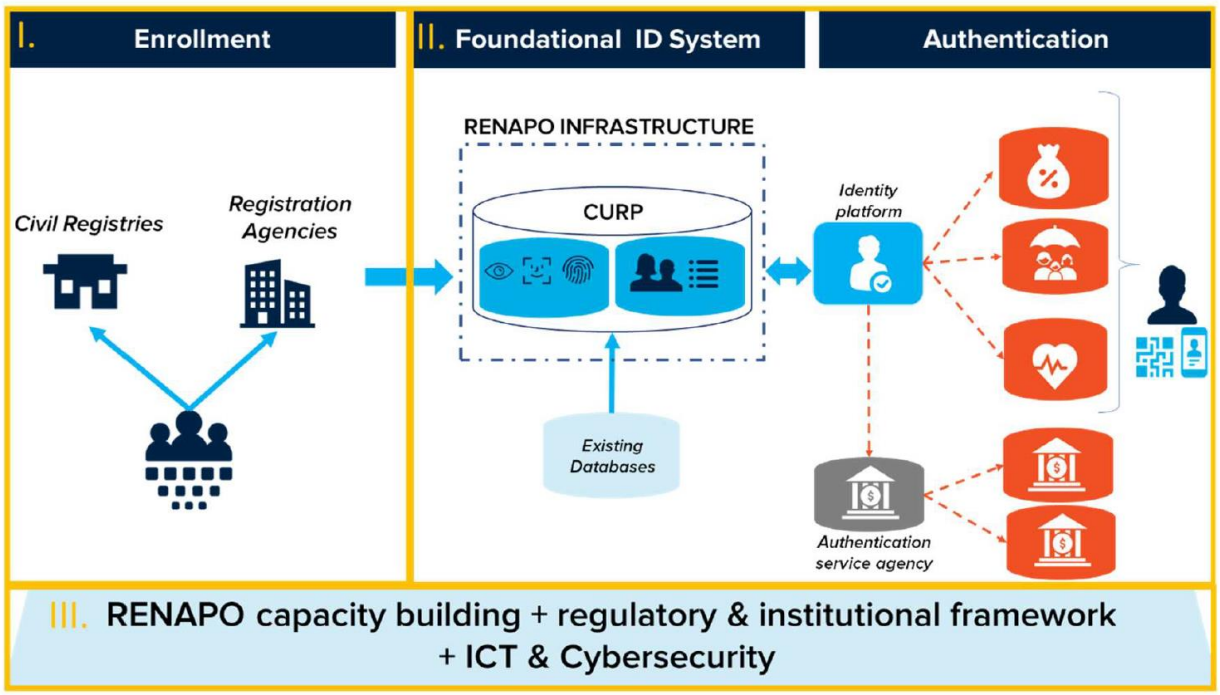
[13] RENAPO - Registro Nacional de Población

three life events: births, marriages, and deaths. While national law requires the states to provide information on vital events to RENAPO, the enrollment processes and data capture practices are not streamlined. Up to 2015, each state had different birth certificate forms and formats, which hindered data consolidation. While the civil registration system has improved in recent years, challenges remain to ensure nationwide coverage and consistency.

The General Population Law mandated that each person be assigned a Unique Population Registry Code (CURP[14]). Difficulties in registration and data management have led to the fragmentation of the identification system. The CURP was established in 1996 to ensure that each person had one unique identifier. CURP enrollment is entered manually based on the birth certificate, without validation or deduplication systems. Consequently, the government may issue multiple CURPs to the same person and, occasionally, assign the same CURP to a different person with the same name. In 2018 there were more than 180 million CURPs, more than the combination of the population of Mexico (127 million) and the number of Mexicans living abroad (approximately 11.8 million).

This project aims to strengthen Mexico´s ID system to ensure a unique identity for all Mexicans and foreign residents, thereby facilitating ID verification and authentication for services and benefits. Figure 10 shows the project structure.

Figure 10: National Digital Identity System Project Structure



[14] CURP - Clave Única de Registro de Población

The project comprises three components:

Component 1: Improving the Quality and Coverage of Civil Registration Services

Subcomponent 1.1: Support for the implementation of the Registration and Identity System (SID) and of the enrollment:

- Development of the SID subsystem for biometric data registry using common standards and interfaces to link biometric and biographic data to the CURP;
- Upgrading technological infrastructure to implement the SID in the federal entities to reach national coverage;
- Supporting the development and implementation of the biometric registration strategies to ensure that a critical mass of the population in Mexico is uniquely identified and to safeguard the inclusion of vulnerable people, especially in areas with limited infrastructure for civil registry services; and
- Monitoring and evaluation of the biometric registration strategies.

Subcomponent 1.2: Implementation of communication strategies in the states:

- Design and implement awareness campaigns to highlight the importance of registering vital events and the need to record biometric data to ensure uniqueness;
- Design and implement an enrollment communication strategy with a focus on vulnerable populations, including those particularly susceptible to climate change impacts, taking into account cultural appropriateness for indigenous peoples and Afro-Mexicans, gender aspects to avoid gender biases and stereotypes, and using indigenous radio stations or other means to reach vulnerable groups more effectively;
- Design and implement a two-way communication strategy with the public to hold consultations and provide feedback to RENAPO regarding the SID roll-out; and
- Design and implement a change management strategy for the SID roll-out in the federal entities, implemented by RENAPO in close coordination with CONAFREC and the state-level civil registries.

Component 2: Designing and Implementing the Foundational System and Verification Services

Subcomponent 2.1: Technology for the receipt and enrollment of biometric data:

- Implement an automated biometric identification subsystem, including the provision, installation, and configuration of biometric search engines;
- Design and implement a biometric identity database including the data update and deduplication processes;
- Define and implement standards for biometric data registration;
- Develop interface systems for biometric data capture, including from legacy databases, and standardization and validation processes; and
- Develop and implement arrangements for biometric data registration by actors involved in the enrollment, including civil registries and federal government agencies.

Subcomponent 2.2: Design and implementation of an identity platform:

- Create an Identity platform based on international standards to enlist and certify partners, including Registration Agencies (RAs), Identity Providers (IDPs), and User Agencies (UAs);
- Analyze alternatives for the identity platform design and define the roles of each participant (RAs, IDPs, and UAs); and
- Implement a certification method for all RAs based on standardized processes and requirements.

Subcomponent 2.3: Establishment of the National Personal Identification Service (SNIP):

- Set-up, configure, and roll out identity verification and authentication services;
- Develop delivery channels for online identity authentication, including, among others, a portal and mobile applications;
- Develop and implement remote verification and authentication services, considering different mechanisms and levels of trust;
- Establish a grievance and redress mechanism to answer queries or complaints regarding identity data and error correction;
- Improve specialized technological infrastructure to be resilient to climate-induced shocks and natural disasters; and
- Develop digital services to improve the efficiency and continuity of disaster response management to climate-induced shocks and natural disasters, including mechanisms to authenticate the identity of individuals that do not have the means to prove their claims.

Subcomponent 2.4: Communication campaigns, alliances, and consensus:

- Establish working groups within each of the sectors participating in the identity platform; and
- Design outreach and communication campaigns, including focus groups and service satisfaction surveys, for member agencies of the identity platform, public agencies, private entities, and the general public.

Component 3: Institutional Strengthening of RENAPO and Project Management

Subcomponent 3.1: Strengthening the regulatory framework for SID implementation and verification and authentication services:

- Design operational guidelines and a governance framework, including roles, functions, and institutional arrangements required, procedures to target priority vulnerable populations, and procedures for process continuation and adaptation during natural disasters and other shocks such as pandemics;
- Develop internal manuals to regulate the provision of verification and authentication services;
- Strengthen the security and data privacy protocols to handle personal data, including implementing technological, organizational, and physical data protection measures to ensure the integrity of the database and mechanisms to obtain the users' consent for operations involving personal data; and

- Develop procedures and manuals to mitigate the risk of exclusion in the SID and SNIP, including processes to allow alternative registration methods, exception handling, and enhancements to the current grievance and redress mechanisms.

Subcomponent 3.2: Strengthen RENAPO's institutional capacity to manage the digital ID ecosystem:

- Design the functions and reengineer processes to provide verification and authentication services; and
- Design and implement a capacity development strategy.

Subcomponent 3.3: Update RENAPO's technological infrastructure:

- Strengthen ICT planning and project management capacity;
- Update RENAPO´s technology and telecommunications infrastructure maximizing energy efficiency;
- Strengthen cybersecurity capabilities, including implementing and institutionalizing data audits; and
- Renovate and equip primary data and disaster recovery centers.

Subcomponent 3.4: Develop project management capacity

- Typical project management tasks without specific ICT sector opportunities.

PROJECT STATUS AND IMPLEMENTATION TIMELINE

The World Bank approved the National Digital Identity System project on January 21, 2021. The bank and the borrower are working toward contract signature and declaring the project effective. Implementation is scheduled for 2021 to 2026. Table 7 describes expected annual disbursements.

Table 7: National Digital Identity System Project Annual Disbursements

Year[15]	Annual, $ Million	Cumulative, $ Million
2022	19.7	19.7
2023	45.0	64.7
2024	50.0	114.7
2025	53.7	168.4
2026	56.6	225.0

Figure 11 describes the timeline for the implementation of project activities.

[15] World Bank fiscal year ending June 30

Figure 11: Timeline for Implementation of National Digital Identity System Project Activities

Project Activity	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Development of the SID subsystem for biometric data registry					
Upgrade technological infrastructure to implement the SID in all federal entities to reach national coverage					
Develop and implement the biometric registration strategies					
Design and implement an enrollment communication strategy					
Define and implement standards for biometric data registration					
Develop interfaces systems for biometric data capture					
Develop and implement arrangements for biometric data registration by actors					
Design and implement a biometric identity database					
Create an Identity platform based on international standards					
Implement a certification process for all Registration Agencies					
Develop and implement remote verification and authentication services					
Establish a grievance and redress mechanism					
Design and implement outreach and communication campaigns					
Strengthen the security and data privacy protocols					
Update processes to provide verification and authentication services					
Update RENAPO´s technological and telecommunications infrastructure					

PROJECT COST AND FINANCING

SEGOB will finance the project through a $225 million loan from the IBRD. Table 8 shows a breakdown of project costs by component.

Table 8: National Digital Identity System Project Cost by Component

Project Component	Cost, $ Million
1. Improve the quality and coverage of civil registration services	137.0
2. Design and implement the foundational system and verification services	61.0
3. Institutional strengthening of RENAPO and project management	27.0
Total	***225.0***

U.S. EXPORT OPPORTUNITIES

Export opportunities for U.S. companies for the project include:

- SaaS and cloud-based solutions for ID document management;
- Biometric solutions including data collection instruments, hardware, and software;
- Data center componentry (servers, racks, power, HVAC, site security, et al.);
- Digital operations center equipment (networking hardware, fiber optic cabling and components, power management hardware, et al.);
- Application design, development, testing, and implementation;
- Custom programming;
- Cybersecurity advisory services and solutions;
- Civil servant and operator training; and
- Legal and policy advisory services.

CONTACTS

Project Sponsor	U.S. Trade and Development Agency	U.S. Commercial Service
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Modernization of Public Financial Management Systems	
SUBSECTOR	**Smart Cities and e-Government**
LOCATION	**Mexico**
PROJECT VALUE	**$110 Million**

PROJECT SUMMARY

- The project's objective is to improve the coverage and timeliness of public financial information.
- The project will also strengthen the underlying technology platforms and reduce the fragmentation of systems supporting fiscal management.
- The project spans four components:
  - Strengthening core public financial management systems;
  - Designing and implementing resource management systems;
  - Enhancing the use and transparency of public financial management information; and
  - Strengthening ICT infrastructure and capacity building.
- A $110 million loan from the International Bank for Reconstruction and Development (IBRD) supports the project.

PROJECT BACKGROUND AND DESCRIPTION

The Mexican administration has initiated a broad modernization program to align its public financial management (PFM) practices and systems with international best practices. Improvements in financial information are required to manage resources within the Government's policy agenda for inclusive growth. These improvements will also:

- Contribute to the transparency and efficiency in the delivery of public services and infrastructure; and
- Reduce or eliminate the fragmentation of information systems across the Federal administration.

The project's objective is to improve the coverage and timeliness of public financial information and its use by the Federal Public Administration. Specific goals for the project include:

- Expanding the range of public expenditure management controls and systems;
- Improving the timeliness and consistency of PFM information;
- Reducing the fragmentation of PFM information to support fiscal management; and
- Strengthening the supporting technological platforms for PFM systems.

The project incorporates four components:

Component 1: Strengthening Core Public Financial Management Systems - supports the designing, modernization, and implementation of information systems for core public financial management and the consolidation of practices for the core budgeting, accounting, treasury, and public debt management functions as part of an integrated PFM model under the responsibility of The Ministry of Finance and Public Credit (SHCP[16]) is responsible for the PFM model and the modernization of PFM information systems. Three subcomponents cover these activities:

1.1 Update the Public Financial Management Information System and Governance Model;
1.2 Strengthen Public Financial Management Processes and Controls; and
1.3 Increase the Efficiency and Sustainability of Public Expenditure.

Component 2: Designing and Implementing Resource Management Systems - supports the design, modernization, and implementation of information systems for administrative functions of federal government agencies, including payroll, procurement, and asset management. This component will develop procedures and instruments for more effective integration of resource management functions into core PFM information systems via two subcomponents:

2.1 Optimize Resource Management Processes; and
2.2 Integrate Resource Management Systems into the Financial Management Cycle:
- Design integration and interoperability frameworks between resource management and core PFM information systems;
- Harmonize concepts, definitions, and catalogs, and establish links across administrative and expenditure cycles; and
- Develop standardized interoperability tools to exchange information between resource management and core PFM information systems.

Component 3: Enhancing the Use and Transparency of Public Financial Management Information - seeks to design and implement information systems to strengthen SHCP's analytical capacity for policymaking using fiscal statistics and information generated by the public financial management system. Further, this component focuses on enhancing fiscal transparency practices and strengthening accountability mechanisms through two subcomponents:

3.1 Implementation of Public Financial Management Intelligence Tools; and
3.2 Strengthening Fiscal Transparency.

Component 4: Strengthening ICT and Capacity Building for SHCP - supports strengthening ICT infrastructure and capacity building within the SHCP to implement fit-for-purpose information systems and more robust SHCP technological infrastructure. An integrated platform structure will underpin the enhanced public financial management system and the necessary change management activities. Component 4 includes three subcomponents:

4.1 Strengthening and Expansion of SHCP's Technological Infrastructure:
- Updating the technological architecture underlying SHCP's PFM system;

[16] SCHP – Secretaría de Hacienda y Crédito Público

- Designing and implementing the SHCP's service cloud to support shared services within the Federal Public Administration;
- Designing and implementing enhanced information security policies;
- Designing and implementing a business continuity plan;
- Executing information technology certification and audits;

4.2 Support platforms for the Public Financial Management Information Systems; and
4.3 Change management and project implementation.

The SHCP anticipates a combination of tailor-made and pre-existing software solutions to cover the financial management information system's needs. The Ministry judges this strategy to pose the lowest technical risk. Tailor-made software solutions will support core public financial management systems. In contrast, pre-existing (commercial or open-source off-the-shelf) solutions will cover administrative functions, such as payroll management and business intelligence.

The project will require the acquisition of IT hardware infrastructure. New information systems will provide additional data management capacity to process and store vast transactions. As part of the national ICT strategy, the General Directorate of Technology and Information Security expects to cover required hardware infrastructure needs through private cloud computing services.

PROJECT STATUS AND IMPLEMENTATION TIMELINE

IBRD approved the loan for project implementation on February 6, 2020, and the parties signed on November 5, 2020. The implementation schedule spans 2021 to 2025. Table 9 describes expected annual disbursements.

Table 9: Annual Project Disbursements

Year	Annual, $million	Cumulative, $million
1	7.5	7.5
2	33.8	41.3
3	35.9	77.2
4	24.9	102.1
5	7.9	110.0

PROJECT COST AND FINANCING

IBRD is financing the project with a $110 million loan. A significant budget share is allocated for ICT expenses under Components 2 and 4, as shown in Table 10.

Table 10: Project Budget

Project Component	Budget, $million
1. Strengthening core public financial management systems	36.0
2. Designing and implementing resource management systems	23.0
3. Enhancing the use and transparency of public financial management information	10.0
4. Strengthening ICT and capacity building for SHCP	41.0
Total	***110.0***

U.S. EXPORT OPPORTUNITIES

The upgrading of the public financial management systems offers several opportunities for U.S. companies, including:

- Implementation of off-the-shelf solutions, including payroll management and business intelligence;
- Tailor-made software solutions for public financial management;
- Advisory services, supporting the integration of management systems, interoperability between systems, capacity building, and change management; and
- Cloud computing solutions.

CONTACTS

Project Sponsor	U.S. Trade and Development Agency	U.S. Commercial Service
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Chetumal Free Trade Zone and Smart City	
SUBSECTOR	**Smart Cities and e-Government**
LOCATION	**Mexico (Chetumal, Quintana Roo)**
PROJECT VALUE	**$500 Million**

PROJECT SUMMARY

- The Chetumal Free Trade Zone (RFE) and Smart City will create 70,000 new jobs for Southern Quintana Roo by 2040.
- The State of Quintana Roo will implement the project in four stages on a plot of over 300 hectares along the Hondo River facing Belize.
- Due to its smart city component, the Confederation of Industrial Chambers of Mexico (CONCAMIN) has selected the project as one of 13 initiatives throughout Mexico to be part of its national smart city program.

PROJECT BACKGROUND AND DESCRIPTION

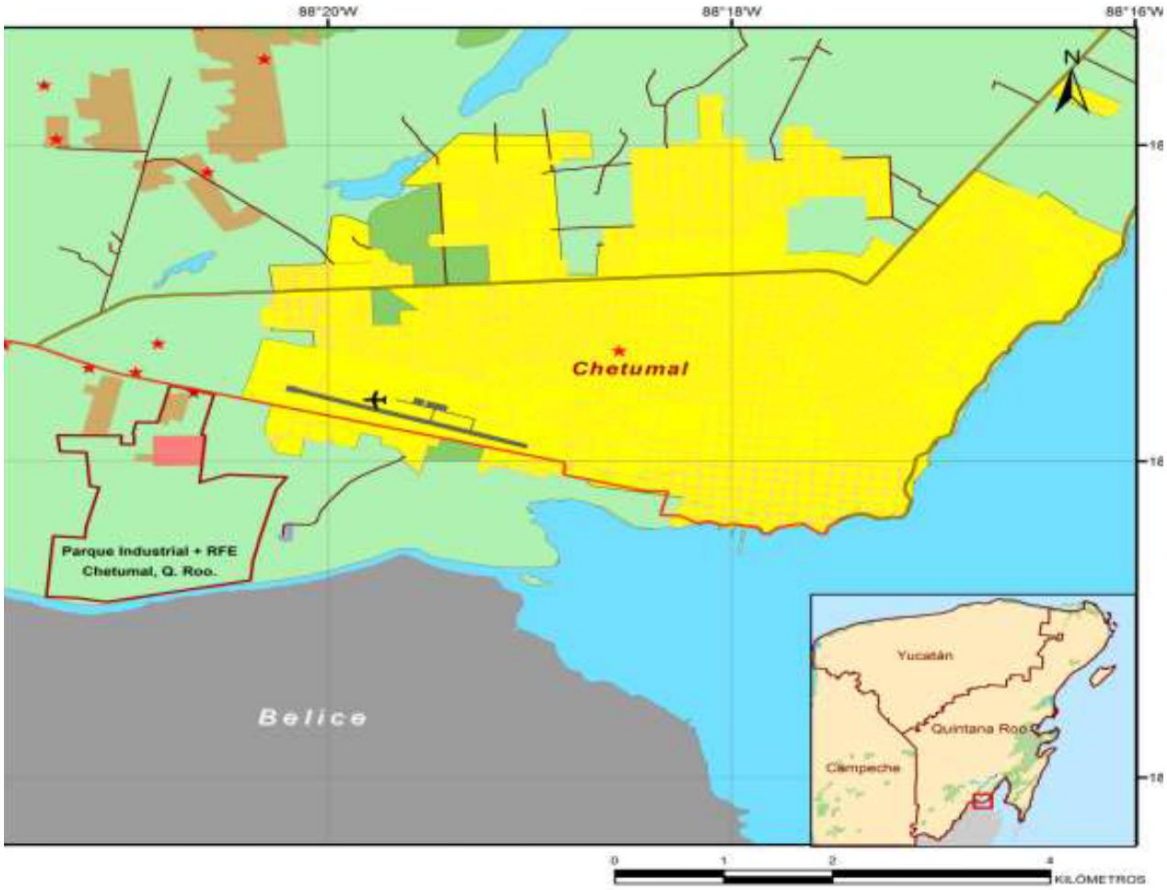
The Chetumal RFE and Smart City is an ambitious industrial park in the southern part of the State of Quintana Roo. The project will drive private sector investment in the region, diversifying a tourism-dependent economy. Incentives to attract companies to the project include subsidies for:

- Payroll taxes;
- Vehicle taxes;
- Beverage licenses; and
- Property registration fees.

Figure 12 shows the traffic circle entrance to the industrial park. Figure 13 depicts the project's strategic location, with access to more than 200 million consumers within a 1,000-mile radius. The Chetumal RFE and Smart City will cover over 300 hectares when fully built over four implementation phases described in Figure 14.

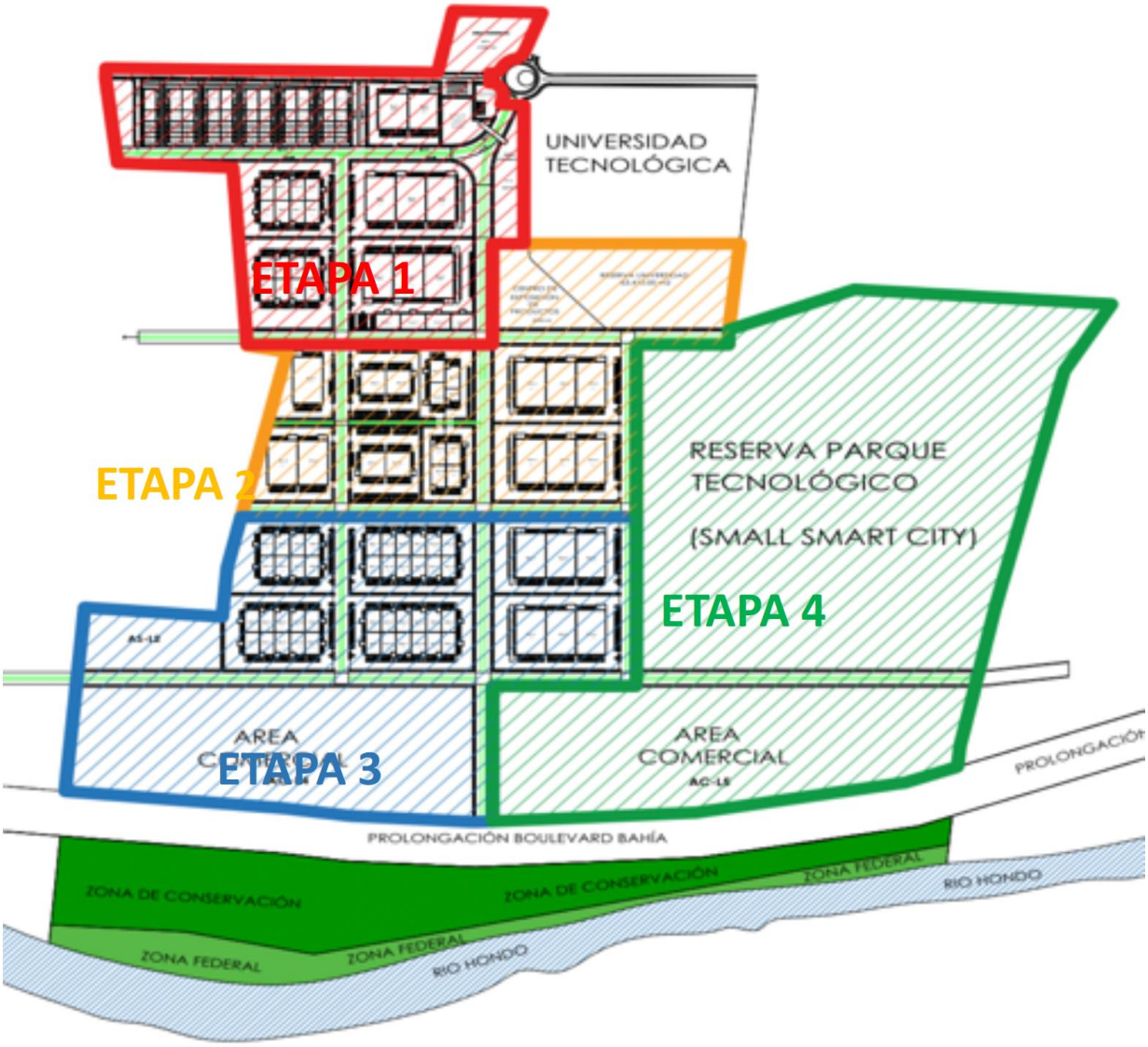
Figure 12: Entrance to the Chetumal RFE[17] and Smart City

Figure 13: Location of Chetumal RFE and Smart City



[17] RFE – Recinto Fiscalizado Especial – Free Trade Zone

Figure 14: Four Phases of Project Implementation



The first project phase covers 40 hectares and contains:

- Two industrial buildings of 4,800 m^2 each, subdivided into individual warehouses of 300, 600, and 1,200 m^2 each;
- A small commercial area; and
- Support services.

Over 40 companies have expressed interest in the first phase, representing industrial sectors including textiles, infrastructure, logistics, manufacturing, and technology. The first companies to set up operations in this phase are BioAqua, Markins, and DataComm.

Chetumal will design the second phase for larger operations. Eight 3,000m^2 and three 6,000m^2 buildings will subdivide into a total of 68 warehouses.

Chetumal will gradually roll out the project's smart city component. DataComm, an initial phase 1 participant, is setting up a data center. Phase 2 will focus marketing efforts for Industry 4.0 endeavors. All steps include fiber optic infrastructure.

Phase 4 includes a smart city pilot. Smart city technologies under consideration include:

- Intelligent street lighting;
- Video surveillance;
- Enhanced security and safety solutions;
- Smart parking;
- Smart transit; and
- Smart utility solutions for energy, water, and waste.

Chetumal will roll out successful elements of the smart city pilot to the rest of the city. The city is one of 13 Mexican municipalities selected by CONCAMIN as a candidate for its smart city initiative.

PROJECT STATUS AND IMPLEMENTATION TIMELINE

Chetumal has completed preliminary planning and obtained all permits and licenses, including:

- Master planning;
- Industrial development program;
- Environmental impact and license;
- Concession of the customs regime;
- Creation of the master trust;
- Decrees of fiscal incentives from three levels of government;
- Construction permits; and
- A business plan.

Groundbreaking occurred in 2019. The first four industrial warehouses began commercial activities in August 2021.

Chetumal expects the following timeline:

- Phase 1 construction during 2022;
- Phase 2 completion by the end of 2023; and
- Phases 3 and 4, including the smart city component, are to begin implementation in 2024.

PROJECT COST AND FINANCING

Chetumal estimates the total investment for the four phases of the project to reach 11 billion pesos, or over $500 million. This amount includes public sector seed capital and private sector investment by companies ultimately located within the industrial park.

The state government of Quintana Roo and the Secretariat for Economic Development have already invested 132 million pesos (over $6 million), primarily for interior roadways, engineering, and permitting. Planned public sector seed capital expenditure will be 900 million pesos (over $40 million) through 2023.

U.S. EXPORT OPPORTUNITIES

The smart city portion of the project requires a wide range of ICT systems, software, and services:

- Smart city infrastructure:
  - Wireless communications infrastructure;
  - City service operation centers; and
  - Smart city ICT infrastructure planning and execution.
- Smart city applications;
  - Smart parking;
  - Transit;
  - Video surveillance;
  - Water and waste management;
  - Lighting;
  - Energy; and
  - Smart security & safety.

CONTACTS

Project Sponsor	U.S. Trade and Development Agency	U.S. Commercial Service
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Cemex Digital Transformation 4.0	
SUBSECTOR	**Internet of Things (IoT) and Artificial Intelligence (AI)**
LOCATION	**Mexico and Globally**
PROJECT VALUE	**$150 Million**

PROJECT SUMMARY

- CEMEX initiated its digital transformation in 2014 and launched *CEMEX Go*, an integrated customer service platform, in 2017-18.
- For 2022 and beyond, the CEMEX digital transformation program will continue, focusing on three areas:
  - Further customer-focused innovations integrated within *CEMEX go*;
  - Management innovations taking advantage of an extensive digital ecosystem; and
  - Roll out Industry 4.0 solutions across all productive assets, enabling a shift from preventative to predictive maintenance and achieving additional operational efficiencies.

PROJECT BACKGROUND AND DESCRIPTION

CEMEX S.A.B. de C.V. (CEMEX) is a Mexican multinational building materials company headquartered in San Pedro (near Monterrey), Mexico. The company manufactures and distributes cement, ready-mix concrete, and aggregates in more than 50 countries and is one of the largest suppliers globally.

CEMEX is well-positioned and has taken significant strides in digital transformation. Its 2017 integrated report was titled "Leading the Industry's Digital Transformation." In 2017, the company launched *CEMEX Go*, an omnichannel platform to cover the complete construction-industry customer journey. *CEMEX Go* covers all customers and geographies while fully integrating with business backend systems, as shown in Figure 15.

Figure 15: *CEMEX Go*, an Omni-Channel Digital Suite of Customer Services

CEMEX Go was launched in 2017 for the North American market and then rolled out in 2018 to all CEMEX geographies. In 2021, CEMEX reported over 40,000 customers connected to the platform, representing 90 percent of the company's global business volume. The company processes over 60 percent of the company's orders through the system.

Key functionalities of *CEMEX Go* include:

- Product search;
- Order Placement;
- Delivery tracking;
- Invoice Management; and
- Online payment.

The development of the *CEMEX Go* digital platform involved a team of more than 500 programmers located across three continents: Monterrey, Mexico; Prague, Czech Republic; and Chennai, India. The company developed the first version delivered to the market over 24 months. CEMEX continues to add new features and improvements.

The company's digital ecosystem facilitated the development of *CEMEX Go*. One key pillar of the ecosystem is CEMEX Ventures, a boutique venture capital fund specializing in digital solutions for the construction industry. Figure 16 describes the CEMEX Ventures investment portfolio. CEMEX Ventures runs an annual startup competition in the construction sector in five categories:

- Carbon footprint mitigation;
- Supply chain management;
- Efficient job site and build environment;
- Advanced building materials; and
- New construction methods.

Figure 16: CEMEX Ventures Investment Portfolio

Another pillar of CEMEX's digital ecosystem is Neoris, a digital business transformation accelerator founded in 1992 to serve the company internally. CEMEX spun off Neoris as an independent company in 2000. Headquartered in Miami, FL, USA, the company now has a global network of 27 offices and over 4,500 employees. The final pillar of the company's digital ecosystem is strategic partners.

For 2022 and beyond, CEMEX's digital transformation will continue along three lines:

- Further customer-focused innovations integrated within *CEMEX Go*;
- Management system streamlining known as "Working Smarter"; and
- Adoption of Industry 4.0 technologies known as "CX 4.0 Operations".

One example of customer-focused innovation CEMEX will continue to pursue and upgrade is a cloud-based solution, Arkik, for the CEMEX ready-mixed concrete (RMC) business. *CEMEX Go* fully integrates Arkik. Many of CEMEX's wholesale cement customers who supply RMC have adopted Arkik. Arkik already manages hundreds of RMC products and their unique recipes. In 2022, CEMEX will roll out dynamic pricing for Arkik. The company will also incorporate delivery timing management. This capability is critical to match workforce and activity planning at construction sites and ensure product quality since suppliers must deliver within a three-hour time slot or the RMC expires. Dynamic, time-of-day pricing will provide greater flexibility for RMC customer decision-making.

CEMEX will roll out CX 4.0 Operations to its production facilities during 2022-2024. Components of the Industry 4.0 transformation include:

- AI-assisted operations to increase production capacity, improve product quality, and reduce energy consumption;
- Machine learning and use of drones to manage on-site inventories; and
- Advanced analytics models and IoT sensors to predict failures, schedule maintenance, and optimize processes, resulting in considerable cost reductions.

Expected benefits of implementing CX 4.0 Operations, as demonstrated by existing CEMEX pilot applications, include:

- Raw material and energy efficiency enhancements;
- Increased outputs;
- Product quality enhancements; and
- CO_2 emission reductions.

CX 4.0 Operations will allow CEMEX to transition from scheduled, preventative maintenance to information-based, predictive maintenance. Optimized maintenance timing will provide a long-term cost reduction, in addition to the one-time benefits from delaying unneeded maintenance procedures.

PROJECT STATUS AND IMPLEMENTATION TIMELINE

As an early mover in digital transformation, CEMEX enjoyed a competitive advantage during the COVID-19 global pandemic. CEMEX digital transformation milestones to date have included:

- 2014: digital transformation launched internally;
- 2017-18: *CEMEX Go* launched to the worldwide customer base; and
- 2019: Construrama.com launched as a digital sales platform.

Future targets for the digital transformation include:

- 2022: Introduce dynamic, time-of-day pricing in the Arkik RMC platform;
- 2022 and beyond: Streamline management systems under Working Smarter; and
- 2022-2024: Roll-out CX 4.0 Operations to all 54 cement and ready-mix plants, cement quarries, aggregate quarries, asphalt plants, depots, and terminals.

PROJECT COST AND FINANCING

As is typical for digital transformations in multinational companies, CEMEX has not published fixed budgets for the efforts planned for 2022 to 2024.

The company has announced expected savings of 10 percent from implementing CX 4.0 Operations. Maintenance capital expenditure is approximately $750 million annually. We estimate operational maintenance personnel, materials, supplies, and contracts to match this amount. Therefore, this element of CEMEX's digital transformation could result in at least $150 million in savings annually. Accordingly, we estimate an implementation budget of at least $150 million.

U.S. EXPORT OPPORTUNITIES

U.S. technology company capabilities align well with likely CEMEX needs under the next phase of its Digital Transformation. Export opportunities will include:

- Artificial Intelligence (AI):
  - Cement- and quarry-specific applications, AI tools, and software development;
  - Predictive maintenance solutions; and
  - Technical and business advisory services.
- Cloud Computing:
  - High-capacity remote location-to-data center technologies;
  - Edge computing and cloud center access; and
  - Technical advisory services.
- Internet of Things (IoT):
  - Equipment monitoring sensors; and
  - Local network hardware, management software, and cybersecurity.

CONTACTS

Project Sponsor	U.S. Trade and Development Agency	U.S. Commercial Service
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Annex A: ICT Sector Overviews

A1 Terrestrial Communications Network Infrastructure: Telephone, Internet, and Broadband

A1.1 Sector Overview

The vast majority of ICT network infrastructure resides on land. Nonetheless, critical transmission infrastructure also exists in space (satellites) and on the ocean floor (see *Subsea Communications Infrastructure*).

Communications networks may be wired, wireless, or a combination of the two and may be as simple as the connection of devices within a home or as complex as serving millions of subscribers throughout a country or across the globe. Although modern technology has blurred the lines in terms of ICT networks and service crossovers, three key areas represent the majority of global communications:

- Telephony;
- Broadband; and
- Internet.

Terrestrial communications network infrastructure spans:

- Hardware and devices;
- Software and firmware;
- Network equipment;
- Supporting systems such as power, cooling, security, and dedicated facilities,
- Computing, application, and content platforms; and
- Related services, including telecommunications, broadband, internet access, and service delivery.

A1.1.1 Telephony

For many decades, telephony was the principal mode of remote human communications. First introduced conceptually by Antonio Meucci, in 1871, Alexander Graham Bell is more generally recognized as the inventor of the telephone. Telephony remained primarily analog/wired until the 1970s, when Martin Cooper, a Motorola engineer, developed the first-generation mobile telephone. In 1979, Nippon Telephone and Telegraph (NTT) deployed the first mobile network (using analog signals). In 1987, various European nations agreed to the use of GSM, or the second generation of mobile telephony -- digital, cellular, and with uniform standards. The adoption of mobile telephony was rapid thereafter, as shown in Table 11.

Table 11: Evolution of Mobile Telephony[18]

Generation	Speed	Technology	Key Features
1G (1970-1980s)	14.4 Kbps	AMPS, NMT, TACS	Voice only
2G (1990-2000)	9.6/14.4 Kbps	TDMA, CDMA	Voice and data
2.5-2.75G (2001-2004)	171.2 Kbps 20-40 Kbps	GPRS	Voice, data and web mobile internet, low-speed streaming services, and e-mail services
3G (2004-2005)	3.1Mbps 500-700 Kbps	CDMA2000 (1xRTT, EVDO) UMTS and EDGE	Voice, data, multimedia, support for smartphone applications, faster web browsing, video calling, and TV streaming
3.5G (2006-2010)	14.4 Mbps 1-3Mbps	HSPA	All 3G capabilities with enhanced speed and mobility
4G (2010-present)	100-300 Mbps 3-5 Mbps 100 Mbps WiFi	WiMAX LTE WiFi	High speed, high-quality voice over IP, HD multimedia streaming, 3D gaming, HD videoconferencing, and worldwide roaming
5G (2019 forward)	1-10 Gbps	LTE advanced schemes OMA and NOMA	Super-fast mobile internet, low latency network for mission-critical applications, Internet of Things, security and surveillance, HD multimedia streaming, autonomous driving, and smart healthcare applications

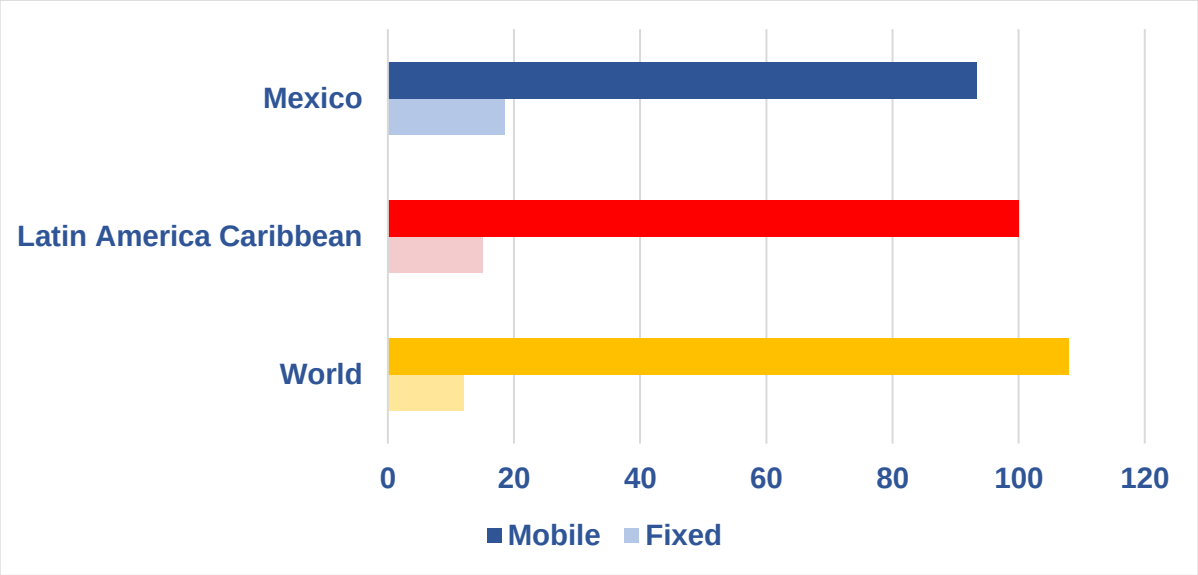
From 1987 to the present, the world has witnessed several new generations of mobile telephony. Each successive innovation provides faster speed, lower latency, and a wider range of capabilities in terms of content transmission capability. The current focus is on the successful implementation of 5G technology, which offers the ability to handle standard voice and data communications and the ability to power Internet of Things (IoT) devices, artificial intelligence (AI), and a wide array of other data-intensive applications.

While fixed telephony still exists worldwide, mobile telephony has been a boon to economically developing societies, giving more citizens telephone access more quickly due to less cumbersome infrastructure installation requirements. Typically, countries with earlier economic development trajectories have higher remaining use of fixed telephony, while those later-to-develop have higher

[18] RFPage.com

mobile to fixed telephone usage levels. Relative fixed and mobile telephony usage in Mexico is shown versus regional and global benchmarks in Figure 17. Mexico exceeds both world and regional averages for fixed telephone subscriptions on a population-adjusted basis. Still, it lags both regional and world averages for mobile telephone, despite being in the top 15 countries globally for total mobile subscriptions and second in the region.

Figure 17: Fixed and Mobile Telephone Usage, 2020 – Subscriptions per 100 People[19]



New technology developments include:

- Deployment of 5G (fifth generation) mobile telephony -- with faster speeds, lower latency, and ability to carry vast amounts of information, 5G will make demanding IoT and AI applications more feasible.

- Expanded use of SD-WAN (software-defined wide area network) -- this cloud-based architecture will continue the path of abstracting software from hardware to provide more elastic traffic management and WAN virtualization.

- Development of a sixth-generation (6G) approach to telecommunications -- using frequencies between 100 GHz and 1 THz. Still, in its early development stages, industry experts expect 6G may require a decade of development but could offer speeds up to one terabyte (TB) per second. That is the equivalent of 142 hours of movies delivered in one second.

[19] World Bank https://data.worldbank.org/indicator/IT.CEL.SETS.P2

A1.1.2 Internet

The internet is a global computer network consisting of interconnected networks using standardized communication protocols. It links smaller computer networks, including commercial, educational, governmental, and others, using the same communications protocols. Also called the World Wide Web (the terms are frequently used interchangeably), technically, the internet comprises the physical infrastructure elements. The World Wide Web is software (i.e., the extensive collection of webpages connected by hyperlinks) and is an internet service.

The internet effectively began in 1965, when Lawrence Roberts and Robert Merrill connected two computers via a low-speed telephone line, one in Massachusetts and one in California. By 1969, a better-developed version of the internet, ARPANET, was demonstrated among computers at Stanford University and the University of California at Los Angeles (UCLA). By 1995, or in just under 25 years, 16 million people had begun using the internet. By 2005, a billion users were accessing the internet, and as of 2019, over 4 billion[20]. Today, citizen internet access and usage are considered barometers of the economic development of nations.

As the internet has developed, rapid changes to hardware, software, and networking technologies have increased utility and speed. Networks have moved from telephony-based to high-speed, high-capacity fiber optic cables and wireless. Content has shifted from simple text to dense streaming for video, photographic, and music content worldwide. Access has moved from desktop computers to small mobile devices, especially cellular phones. Users may now connect anywhere in the world with but milliseconds of lag from anywhere else.

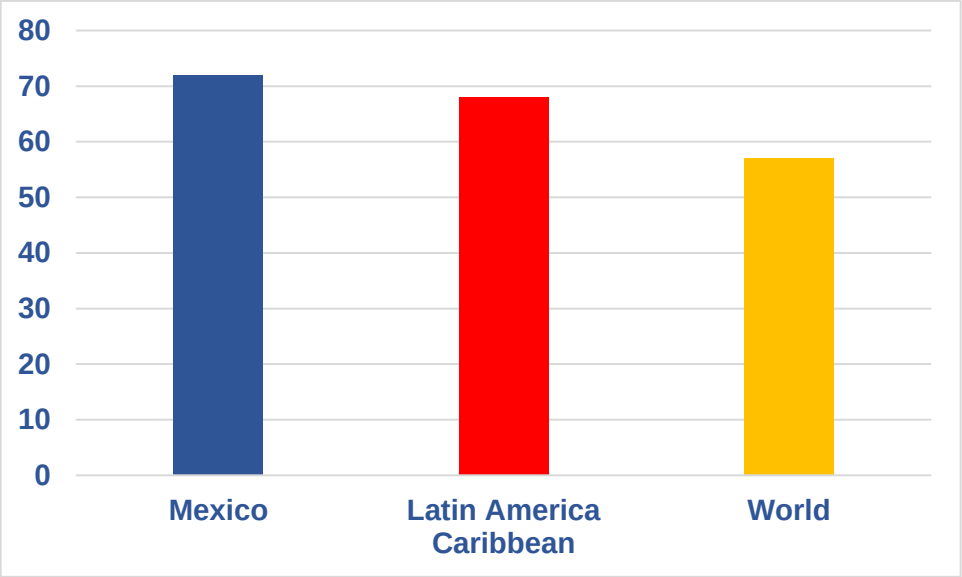
Technologies in development to extend internet utility include:

- **5G Data Networks** – super fast data networks allowing better streaming capabilities at lower latency.
- **Internet of Things (IoT)** -- increased bandwidth allows for high-data-intensity new applications such as autonomous driving vehicles, smart machines, and advances in telemedicine, including predictive diagnostics.
- **Computer Vision** – automated, digital visioning.
- **Artificial Intelligence** -- computer system ability to perform tasks previously requiring human intelligence (e.g., visual perception, speech recognition, decision-making, and translation between languages).
- **Virtual and Extended Reality** – used today primarily for entertainment and simulation, training, and other professional uses. The user allows the computer to create a virtual world and block out the real one.
- **Blockchain** – a digital ledger to record transactions secured via encryption and decentralized. Cryptocurrencies are the medium of exchange, including perhaps the best known Bitcoin, along with others such as Ether (Ethereum), Binance, zCash, Monero, and Facebook's Libra, which is shifting in scope due to regulatory pressure.

[20] HootSuite

Internet usage (i.e., the percent of the population using the internet) varies widely globally, as shown in Figure 18. Mexico exceeds both global and regional internet penetration levels.

Figure 18: Internet Usage Penetration - 2020[21] (Percent of Population Using the Internet)



A1.1.3 Broadband

Broadband is a high-capacity transmission technique using a wide range of frequencies, enabling a large number of messages or other content to be communicated simultaneously. The term broadband commonly refers to high-speed internet access that is always on and faster than the historical dial-up access. Several high-speed transmission technologies comprise broadband, including:

- **Digital Subscriber Line (DSL)** - a wireline transmission technology over traditional copper telephone lines already installed to homes and businesses with transmission speeds ranging from several hundred kilobits per second (Kbps) to millions of bits per second (Mbps).

- **Cable Modem** - broadband provided using the same coaxial cables that deliver pictures and sound to a television. Cable modems are typically external devices with two connections, one to the cable wall outlet and a computer, and operate at transmission speeds of 1.5 Mbps or more. It is possible both to use broadband and watch television simultaneously.

- **Fiber** - converts electrical signals carrying data into light and sends the light through transparent glass fibers about a human hair's diameter. Fiber transmits data at speeds far exceeding current DSL or cable modem speeds, typically by tens or even hundreds of Mbps. Fiber may run to the customer's home or business, the curb outside, or a location somewhere between the provider's facilities and the customer.

[21] World Bank

- **Wireless** - a radio link between the customer's location and the service provider's facility, either mobile or fixed. Wireless technologies using longer-range directional equipment can provide broadband service in remote or sparsely populated areas where DSL or cable modem service would be costly. Speeds are generally comparable to DSL and cable modem. An external antenna is usually required.

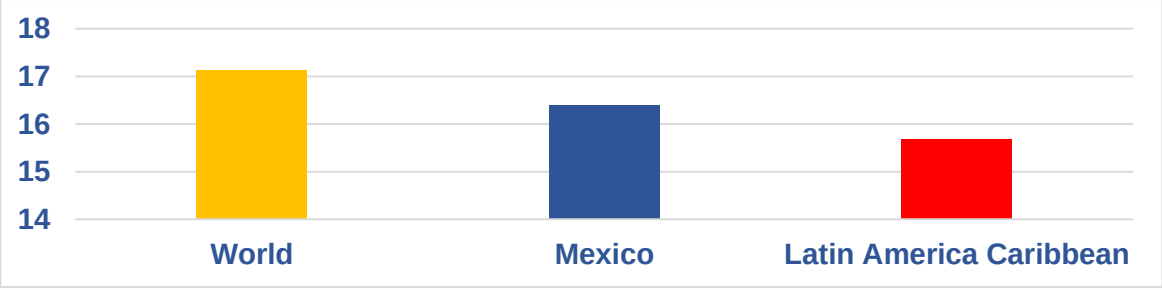
- **Satellite** - satellites orbiting the earth provide vital links for telephone and television service and create wireless links for broadband useful for serving remote or sparsely populated areas. Consumers may expect to receive (download) at 500 Kbps and send (upload) at 80 Kbps. These speeds may be slower than DSL and cable modem, but they are about ten times faster than the download speed with dial-up Internet access. Extreme weather conditions, however, may cause service to be disrupted.

- **Broadband over Powerlines (BPL)** delivers broadband over the existing low- and medium-voltage electric power distribution network. BPL speeds are comparable to DSL and cable modem speeds. Power lines are installed virtually everywhere, thus alleviating the need to build new broadband facilities.

Broadband's origins date to the 1960s. By 1969, prestigious colleges on the U.S. east and west coasts had 50Kbps or better broadband connections. In 1984, these colleges adopted T1 (voice and data) lines, forgoing the use of the previous 50Kbps channels. In the early 1990s, businesses began to use broadband, and by 2000-2001, home use was growing rapidly. Since the dawn of the millennium, global citizen access, upload and download speeds, and service consistency and reliability have continued to improve.

The use of fixed broadband per 100 people in the Latin America and Caribbean region varies widely. As shown in Figure 19, Mexico exceeds regional levels but slightly lags the world average.

Figure 19: Fixed Broadband Subscriptions per 100 People, 2020[22]



New broadband technologies overlap those for telephony and the internet and include implementation of the 5G network and eventual development of a 6G network. Certain futurists are beginning to ask the question as to whether fixed, even fiber-based, broadband may become obsolete in future telecommunications generations with speeds above 1Tbps, assuming wireless technologies can solve issues such as line-of-sight.

[22] Ibid

A1.2 Terrestrial Communications Network infrastructure - Investment Outlook

The value of global telecommunications services was $1.7 trillion in 2019[23] and is expected to grow at a compound annual growth rate of 5 percent from 2020 to 2027. Continued increases in demand for consumer wireless telephone services, mobile access, and cloud-based technologies drive demand for high-speed telephone, internet, and broadband connectivity. The commercial segment has recently accounted for the most growth despite strong consumer demand. Commercial application foci include data reliability and quality, both for customers and internally for videoconferencing, high-security intracompany networks, and corporate calling and texting.

Global internet (web) hosting services reached $61 billion in 2018 and will grow at a compound annual growth rate of over 15 percent through 2026.[24] Growth drivers include expanding individual consumer demand for greater access to web-based shopping, household device connectivity, and mobile access.

Global broadband services were valued at $327 billion in 2019 and projected to grow at a compound annual growth rate of nine percent through 2027.[25] The digital transformation of several industry verticals, along with ever-expanding consumer demand and access, is driving growth. While the COVID-19 global pandemic has slowed growth in some sectors, broadband usage for e-learning and digital healthcare has grown rapidly.

Overall, this sector's market size in the Latin American/Caribbean region exceeded $100 billion in 2018. Growth in multichannel and fixed broadband/internet services outpaced that in fixed and mobile telephony, which are more mature technologies.[26]

A brief overview of the Mexican sector follows.

A1.3 Mexico

Since 2010, the Mexican telecommunications market has consistently outpaced GDP growth due to demand for mobile telephony, broadband, and broadcasting. As of 2020, Mexico has a wireless penetration of 93.45 percent, with more than 120 million active lines. The country was eleventh globally in fixed broadband, with over 21 million total subscriptions and 16.45 per 100 Inhabitants. Nearly 72 percent of the population use the Internet, or about 92 million people.

The technologies employed for domestic connectivity are coaxial cable (39 percent), DSL (36 percent), fiber optic (24 percent), and satellite (0.1 percent). Telmex is the dominant player in fixed broadband with a 50 percent market share in terms of subscriptions compared to Televisa, Mega Cable, and Total Play at 24.3, 16, and eight percent, respectively. Mexico offers 2G, 3G, and 4G cellular services for mobile telephony, with carriers readying for 5G.

[23] Grandview Research
[24] Fortune Business Insights
[25] Grandview Research
[26] S&P Global Market Intelligence

Mobile and fixed broadband speeds in Mexico averaged 34.33 and 54.88 Mbps for download, 12.98 and 21.53 Mbps for upload, and 48 and 23 milliseconds for latency, respectively, in September 2021. These levels position Mexico at 74th and 80th globally for mobile and fixed broadband on a speed basis, respectively.[27]

Mexico is the third-largest export destination, after Hong Kong and Canada, for U.S. telecommunications equipment (HS 8517), accounting for roughly 10 percent of U.S. total export sales in this category in 2020. Investments in infrastructure and increased connectivity tend to drive growth.

Historically, Mexico's terrestrial telecommunications sector was challenged by a near-monopolistic structure. After establishing measures to improve competition and strengthening the IFT's regulatory powers, reforms created a more attractive investment climate motivating new players to enter the market. In 2015, U.S. supplier AT&T acquired Iusacell and Nextel Mexico, Mexico's third- and fourth-largest carriers. AT&T has since invested in modernizing and expanding its network in Mexico. Similarly, Mexico's largest wireless carrier, Telcel, has invested heavily in technology and infrastructure, as have others.

The policy of the Mexican Government is to provide universal connectivity, primarily through its *Internet para Todos* (Internet for All) program, profiled in this Resource Guide. The program seeks to create internet hot spots in public areas, including town squares, schools, hospitals, and government buildings.

Other Terrestrial Communications projects profiled in this Guide include:

- IFT's 2021-25 Roadmap (national);
- Digital Transformation and Social Inclusion (national);
- Financing for Rural and Semi-Urban Telecom SMEs (national); and
- Tabasco Telecommunications Master Plan (state).

[27] SpeedTest https://www.speedtest.net/global-index/mexico

A2 Subsea Communications Infrastructure

A2.1 Sector Overview

Subsea (or submarine) fiber optic cables are effectively the backbone of the internet today. They permit countries and continents to share information across long geographic distances. While satellite communications are highly effective, subsea fiber optic cable today is more reliable and cost-effective. In the future, some competition from Low Earth Orbit (LEO) satellites is likely.

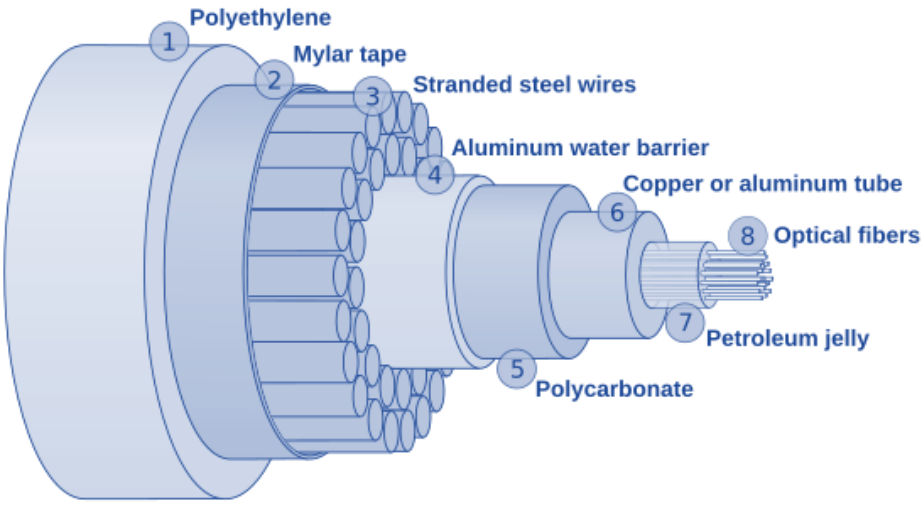
Subsea fiber optic cables are laid on the seabed to provide a high-capacity means of transferring large amounts of information and data. Using the seabed for cable laying allows for route shortening and optimization, which reduces transmission lag (latency) and also avoids terrestrial security issues such as natural disasters and human acts such as vandalism.

Subsea cables are designed and manufactured to:

- Be installed underwater and take into account:
  - Ambient temperature (both sea and land);
  - Burial/water depth and associated pressures;
  - Nature of shore approach; and
  - Cable length.
- Be laid on the rugged and rocky seabed and be buried near the shore approach.
- Withstand marine animals, tsunamis, volcanic activity, and trawls used by fishermen.

A typical subsea fiber optic cable includes numerous components, of which all but the fibers themselves are protective of the glass optical strands at the center. The optical fibers carry digital data in the form of light, as shown in Figure 20.

Figure 20: Subsea Fiber Optic Communications Cable Construction[28]



[28] Fibertronics, U.S. Patent No. 4,278,835

Typical subsea fiber optic cables are just under an inch in diameter and weigh 2.5 tons per km. Manufacturers typically add extra armoring for cables and cable ends residing near a shoreline. The optical fibers are about the diameter of a human hair and are fashioned of highly pure glass coated with a high-performance polymer such as a polyimide.

Installers typically bury near-the-shoreline cable sections under the seabed for extra protection. Before installation, route studies assess preferred alternatives to avoid hazards such as fault lines, anchoring zones, fishing areas, etc. The shortest cables, such as Google's Junior, connecting Rio de Janeiro and Santos, Brazil, are but a few hundred km. Transcontinental cables run lengths of as many as ten to twenty thousand km.

A laser transmits digital data at one end of the cable installation by firing a light signal down the optical fiber. In the form of the light signal, the data is captured on the other end by a receptor. The optical fiber performs essentially as a mirror. The laser switches on and off to send each bit. Modern fiber systems with a single laser can transmit billions of bits per second, i.e., the laser can turn on and off several billions of times per second. Newer systems use multiple lasers with different colors to fit numerous signals into the same fiber. Fibers are paired within cables, one fiber for each direction.

Fiber optic cables can carry a signal up to about 60 miles (100 km). On a long-distance line, equipment huts at intervals contain equipment to pick up and retransmit the signal, at full strength, down the next segment.

Redundancy is built into cable systems to reduce the impact of cable faults, typically by spreading network capacity over multiple cables. Other cables manage the function of a cable requiring downtime/repair time until repairs are complete. About two-thirds of cable faults result from marine traffic (fishing and anchor dragging), with environmental issues, such as earthquakes, another major fault contributor. Occasionally underwater components fail.

At the ends of a subsea fiber-optic cable are landing points. Landing points are selected to have silty bottoms to allow the line's burial to protect it from damage, mild currents to ensure the cable's positional stability once buried, and minimal marine traffic. Multiple cables frequently share landing points. A landing station may also provide power to subsea amplifiers and repeaters. A cable termination station (which may or may not be the same as the landing station) provides the point at which the subsea cable connects with the high capacity, terrestrial, backhaul system, typically near an area of high communications demand such as major metropolitan areas.

The first subsea fiber optic cable, TAT-8, running between the United States (AT&T), the United Kingdom (British Telecom), and France (France Telecom), was laid in 1988. It could carry 280 megabits per second (Mbps), the equivalent of 40,000 telephone circuits.

As of 2020, roughly 400 subsea optical fiber cables are operational. The highest capacity subsea fiber optic cables operate at more than 100 terabytes per second (Tbps), more than 10 million times the typical home internet connection speed, and the equivalent of carrying 45 million high definition videos simultaneously. The Marea cable, connecting the United States (Virginia Beach,

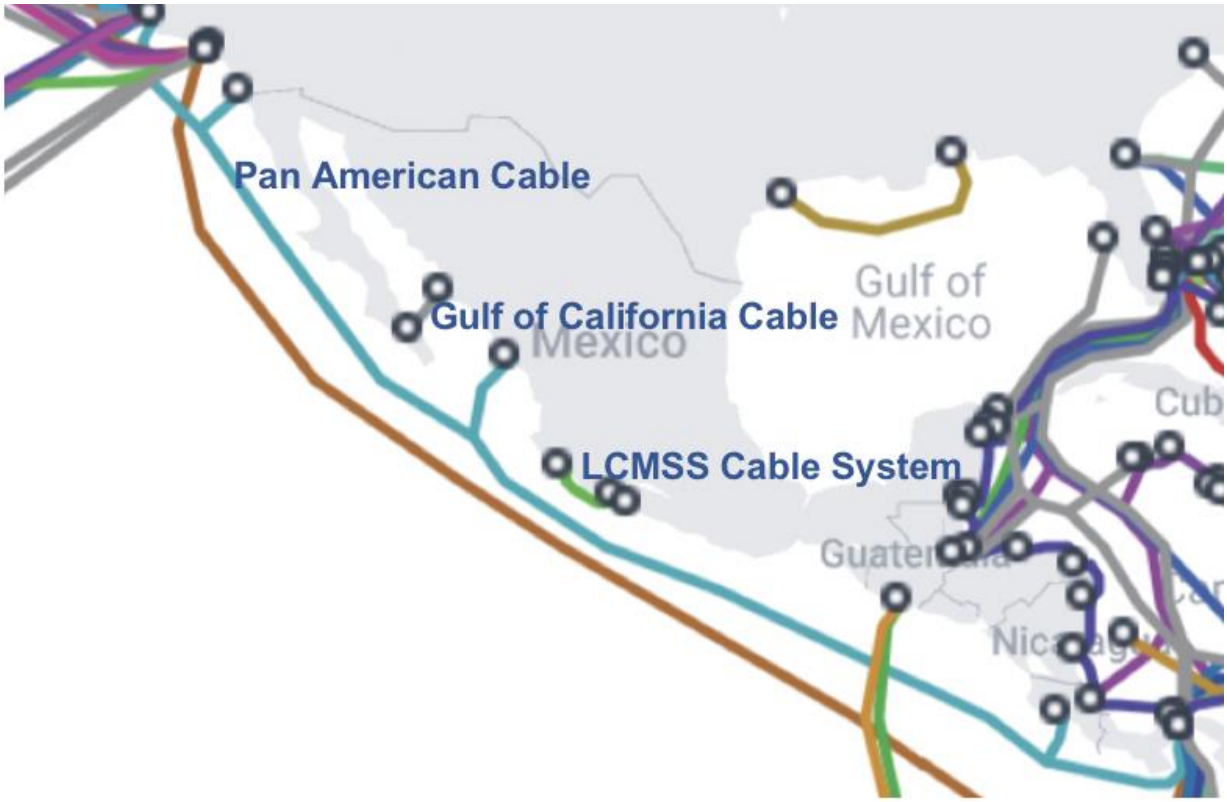
VA) and Bilbao, Spain, has a design capacity of 160Tbps but has demonstrated the ability to run at up to 200Tbps.

Recent technology developments include capacity-enhancing spatial digital multiplexing (SDM) and twisted light spirals. Google Global Networking has recently reported adapting the use of existing subsea fiber optic cable technology to detect and provide early warnings for earthquakes and tsunamis.

A2.2 Subsea Communications Infrastructure - Investment Outlook

The Latin American/Caribbean region hosts and has under construction a total of 68 cable systems and 217 landing stations. Mexico hosts one international and two domestic cables, shown in Figure 21.

Figure 21: Mexico Subsea Fiber Optic Cable Map[29]



The global subsea fiber optic cable market is approximately $14 billion, with a projected growth rate of 13 percent through 2025[30]. Today, the U.S. and China represent a combined 42 percent of the global market, with the Latin American/Caribbean market estimated to represent a 10 percent share, or about $1.4 billion.

[29] Submarine Cable Map https://www.submarinecablemap.com
[30] ReportLinker

While historically, telephony and telecommunications companies owned subsea fiber optic cable systems increasingly, content providers such as Amazon, Facebook, Google, and Microsoft are emerging as owners and co-developers of new cables. In addition to the numerous ongoing subsea fiber optic cable projects in South America, this creates unique opportunities for U.S. companies to align with U.S. content providers for new cable development in the northern Latin America and Caribbean region. For example, the GigNet-1, Ocean Networks Caribbean Express, and Seaborn CARICOM cables expect to service Mexico's east coast.

A2.3 Mexico

Mexico has two subsea, fiber-optic-cable landing points on its Pacific Coast for international service, one near Mazatlán and the other near Tijuana. The 10,000 km Pan American Crossing (PAC) subsea cable, owned by Lumen, lands at these sites. This cable runs along the Pacific coasts of the United States (Grover Beach, CA), Mexico, and Costa Rica, terminating in Panama at Fort Amador.

Developers are working toward subsea cable service to Mexico's east coast. The GigNet-1 cable project, profiled in this Resource Guide, will offer Mexican Caribbean connectivity. This new international cable will run from Florida to Cancun. Ocean Networks, Incorporated is developing the CaribbeanExpress cable, connecting the United States (from Palm Beach, FL) to Panama. The company plans branch lines to Mexico (landing at Cancun) and approximately eight other Caribbean and Central American countries. Further, cable developer, Seaborn Networks is exploring a project.

Mexico also has two domestic subsea cables. Owned by Telmex, the 322 km Lázaro Cárdenas-Manzanillo Santiago Submarine Cable System (LCMSSCS) connects Cuidad Lázaro Cárdenas with Ixtapa and Manzanillo. The 250 km Gulf of California cable, owned by Megacable, connects La Paz and Topolobampo.

A3 Data Centers and Cloud Computing

A3.1 Sector Overview

Data centers and cloud computing are closely interrelated. Data centers provide storage for large amounts of digital information. Cloud computing, simply, is accessing and storing information and programs that do not reside on the computer a user is accessing, but rather via the internet, with the data/programs stored remotely in a data center.

A3.1.1 Data centers

Data centers store and assist in the retrieval and processing of large amounts of critical information. Frequently, a data center houses servers/data storage for a specific organization, though multiple customers share many. A data center includes:

- The building/real estate housing storage;
- Storage hardware (servers);
- Server racks and cabinets;
- Power and operational backup systems;
- Environmental controls, especially cooling;
- Cyber and physical security; and
- Anything else deemed necessary to keep the servers running.

A data center may be as simple as a single server or as complex as hundreds of thousands of servers, as shown in Figure 22. The average data center includes tens of thousands of servers and occupies about 100,000 square feet of space. The largest global data centers are in the range of three to seven million square feet. Most data centers, especially large-scale facilities, are sited to avoid natural disasters, thus minimizing downtime risk. Power and cooling are large operational cost contributors and can limit data center scale.

Figure 22: Data Center Exterior and Interior[31]

Data centers segment by:

[31] Amazon Web Services, JAYCor International

- Type – nature of operations;
- Tier (I-IV) – uptime/downtime/redundancy;
- Density – low, medium, high, and extreme;
- Vertical served – e.g., government, telecom and IT, banking and finance, healthcare; and
- Nature of infrastructure – types of electrical, mechanical, and IT systems incorporated.

Data centers types include:

1. **Hyperscale** – typically owned and operated by the company it supports. Hyperscale data centers offer a portfolio of scalable applications and storage to third-party individual and corporate customers. These data centers are typically high-square-footage, high-server-count locations distinguished by an ultra-high-speed, high fiber-count, fiber-optic network. Participants in this sector include AWS (an Amazon subsidiary), Microsoft, Google, and Apple.

2. **Colocation/Wholesale Colocation** – these data centers are typically single-owner sites, where the owner sells or leases space, power, and cooling to other enterprises or hyperscale customers in a specific location. Typical colocation data centers typically service hundreds to thousands of customers. In addition to basic data center capabilities, these facilities often provide technical guidance and, importantly, interconnection services to Software as a Service (SaaS – e.g., Salesforce) and Platform as a Service (PaaS – e.g., Azure) to assist their customers in scaling their businesses with low cost and complexity. Wholesale Colocation data centers typically do not offer Interconnection Services. They tend to service fewer customers than average, as they typically focus on location-specific infrastructure provision for sophisticated enterprise and hyperscale clients.

3. **Enterprise** – an enterprise data center is owned and operated by the company/entity it supports, often at the location of existing company operations. Owners may divide enterprise data centers to host the needs of various businesses within the company's portfolio. Mechanical and electrical services are often outsourced, but the company typically runs the white space (data center operations). Enterprise data centers usually comprise at least ten server cabinets (several hundred servers) but may be much larger.

4. **Telecom** – a telecom data center is owned and operated by a telecommunications or telecom services provider (e.g., AT&T, Verizon, *et al.*) and requires unusually high levels of connectivity and reliability. Telecom data centers are responsible for driving content delivery, mobile services, and cloud services. They may be "lights out" (i.e., physically or geographically isolated) to minimize environmental and human contact and ensure uptime.

5. **Edge** – these are the newest type of data center and are in the early stages of development. Edge data centers will support the Internet of Things (IoT), autonomous vehicles, and other data-intense applications for which content placement close to the user is desirable. Likely to be powered by 5G communications networks to support high data transport requirements and minimize latency, their development will require considerable optical fiber hardware and fiber optics installations. Key characteristics include:

- *Local* – placed near areas served but managed remotely;
- *Small* – same components as a traditional data center but a smaller-than-typical footprint;
- *Fractional* – one of many in a larger, complex network that includes a central enterprise or hyperscale data center; and
- *Mission-critical* – bringing computation and data storage closer to the location where required, improving response times, saving bandwidth, and minimizing latency.

Also, data centers are typically segmented by tiers, defining their annual uptime availability, maximum downtime, redundancy of power paths, and ability to withstand force majeure events, as shown in Table 12.

Table 12: Data Center Tiers[32]

Tier	User Group	Uptime (%)	Annual Downtime (hours)	Power Outage Protection (hours)
1	Small Businesses	99.671	28.8	No redundancy
2	Medium-size Businesses	99.749	22.0	Partial redundancy
3	Large Businesses	99.962	1.6	72
4	Enterprise Corporations	99.995	0.4	96

Technology is changing rapidly in this sector with the development of artificial intelligence (AI), edge and server-less computing, and SaaS (software-as-a-service/online subscription models), all of which move away from historic data centralization. Satellite operator Starlink (part of Elon Musk's SpaceX), which is launching hundreds of Low Earth Orbit (LEO) satellites to provide global broadband coverage (especially to difficult to reach locations), even envisions the addition of extraterrestrial data centers to support its extraterrestrial broadband network.

A3.1.2 Cloud Computing

Cloud computing, in simplest terms, is storing and accessing data and programs over the internet instead of on one's own computer hard drive. More broadly, Cloud computing is a process of delivering and enabling scalable, expandable, almost perfectly elastic software services using internet technologies. Typically provided through a third-party vendor with its own data centers, cloud computing is a means of delivering Software as a Service (SaaS) on a pay-per-use or pay-per-time period basis. Cloud computing provides self-service capabilities with scalable features to users, allowing increased capacity upon requirement. Typical service offerings of cloud computing providers include Infrastructure (IaaS), Platform (PaaS), and Software (SaaS) as a Service, as well as Backend as a Service (BaaS), which is similar to SaaS except directed toward developers, whereas SaaS is directed toward users. In each approach, the user company manages certain functions, and the Cloud Services provider handles others, as shown in Table 13.

[32] ComRent/The Aberdeen Group

Table 13: Cloud Computing Activities by "As a Service" Type[33]

Separation of Responsibilities – "As a Service " (aaS) Formats			
On Premises	**Infrastructure (IaaS)**	**Platform (PaaS)**	**Software (SaaS)**
Applications	Applications	Applications	Applications
Data	Data	Data	Data
Runtime	Runtime	Runtime	Runtime
Middleware	Middleware	Middleware	Middleware
O/S	O/S	O/S	O/S
Virtualization	Virtualization	Virtualization	Virtualization
Servers	Servers	Servers	Servers
Storage	Storage	Storage	Storage
Networking	Networking	Networking	Networking

Data center (and cloud computing) presence varies widely across Latin American and Caribbean countries. Mexico is among the best served regional countries.

A3.2 Data Centers / Cloud Computing Investment Outlook

The global data center business is $135 billion globally, with projected compound annual growth rate (CAGR) estimates ranging from five to ten percent through 2023. The Latin American/Caribbean data center business is approximately five percent of the world total and is projected to grow slightly faster than the global rate. Demand for new regional data centers is driven by government initiatives toward modernization/infrastructure development and employment, along with the growth of private enterprise.

The global market for cloud computing is approximately $15 billion, with a CAGR of 19 percent through 2027.[34] The United States is the largest cloud computing market, representing about one-third of global demand. The Latin American/Caribbean region currently represents about 10 percent of the global market. This region is projected to grow at a CAGR of over 25 percent from 2020 to 2027 (not accounting for likely development lags resulting from the 2020 COVID-19 global pandemic).

Several large U.S. cloud-computing players, including Cisco, Hewlett Packard, IBM, and Microsoft (Azure), are operationally present in South America.

A3.3 Mexico

Mexico currently hosts approximately 153 data centers.[35] Thirty co-location data centers reside in Mexico City, 22 in Queretaro, and 14 in Monterrey. The remaining data centers are scattered regionally.

[33] Assist Software
[34] Report Linker
[35] Cloudscene https://cloudscene.com/market/honduras/all

Mexico City has a connectivity ecosystem beyond its data centers of 77 cloud service providers and 30 network fabrics. With 17 service providers, KIO Networks operates the largest data center in Mexico City, KIO Networks MEX|2.[36]

The city of Queretaro is actively seeking to expand its data center presence through the collaboration of various entities in a triple helix framework:

- Higher education institutions and their research centers;
- Productive sectors and their industry clusters; and
- Regional government entities.

As profiled in this Resource Guide, among the project's goals are the digital transformations of critical industries in the region, particularly automotive and aerospace.

[36] Ibid.

A4 Smart Cities and e-Government

A4.1 Sector Overview

A smart city is a municipality incorporating information and communications technologies (ICT) to improve efficiency, quality, and urban services performance. The ICT tools aid in reducing resource consumption, waste, and overall costs, as well as improving service quality, responsiveness, and transparency. Frequently, ICT smart-city tools provide direct service access and government and community participation to residents.

Typically, more than half of smart-city services are delivered through the public sector. Smart cities and e-Government are closely related. e-Government (short for electronic government) uses ICT networks and devices to provide public services to citizens and other persons residing in a country, region, or municipality. e-Government offers opportunities for more direct and convenient citizen access to government overall, government transparency, and direct provision of government services.

A4.1.1 Smart Cities

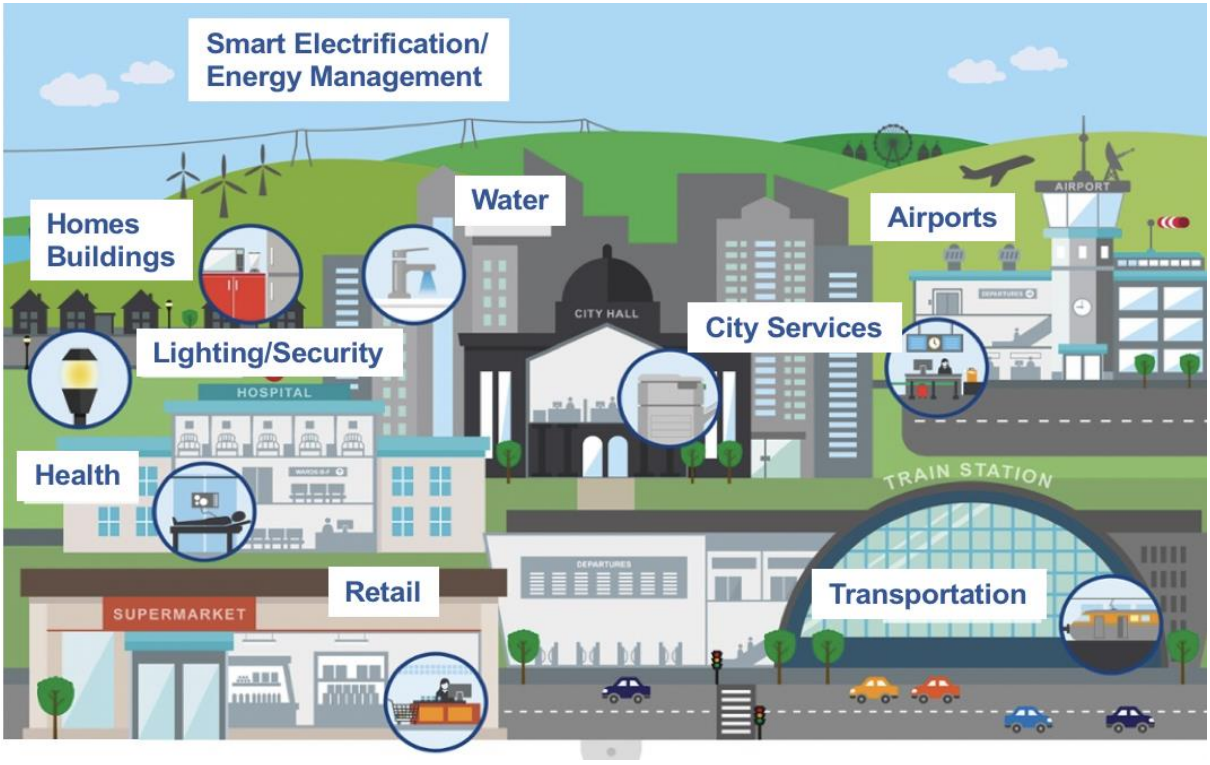
A smart city is a highly digitally connected municipality using information and communications technologies to increase operational efficiency, share information with the public, and improve both the quality of government services and associated citizen welfare. Initiatives typically focus first on infrastructure development, such as reliable electric supply, robust IT digitization and connectivity, and efficient public transportation. Efforts surrounding citizen safety and security, public housing, healthcare, education, and traffic and transportation management, as well as government efficiency and transparency, may be added, as shown in Figure 23.

Today, cities are home to more than half the world's population.[37] The United Nations projects that by 2050, 68 percent of the global population will reside in cities. By 2035, 600 cities will account for approximately 65 percent of global GDP.[38] The continued migration to cities will require new, personalized, and interactive municipal services, many delivered under the smart cities umbrella. For example, in a pilot of three cities, McKinsey and Company found smart cities tools could produce the following results:

- Reduce fatalities by 8–10 percent;
- Accelerate emergency response times by 20–35 percent;
- Reduce the average commute by 15–20 percent;
- Reduce disease burden by 8–15 percent;
- Reduce greenhouse gas emissions by 10–15 percent; and
- Reduce water consumption per citizen by 25-80 liters per day.

[37] McKinsey & Company
[38] Ibid

Figure 23: Smart City ICT Applications[39]



Numerous entities rank smart cities annually. Today, top-ranked global smart cities are primarily located in North America and Western Europe, with Singapore also routinely included. In general, wealthier urban areas are faster to transform, though Asia, with large populations of younger citizens, has also rapidly embraced the smart cities concept, as shown in Table 14.

Lack of sufficient ICT infrastructure has posed challenges to smart city development in certain geographies. In some, such as Asia and the Middle East, initiatives are developing to create new cities that will be smart from the start.

As shown in Figure 24, the National Autonomous University of Mexico, with its over 350,000 students, is developing a smart education and local services support hub in the Latin America and Caribbean region. Smart city development in a Queretaro industrial park is among the project reviews in this Resource Guide.

[39] International Electrotechnical Commission

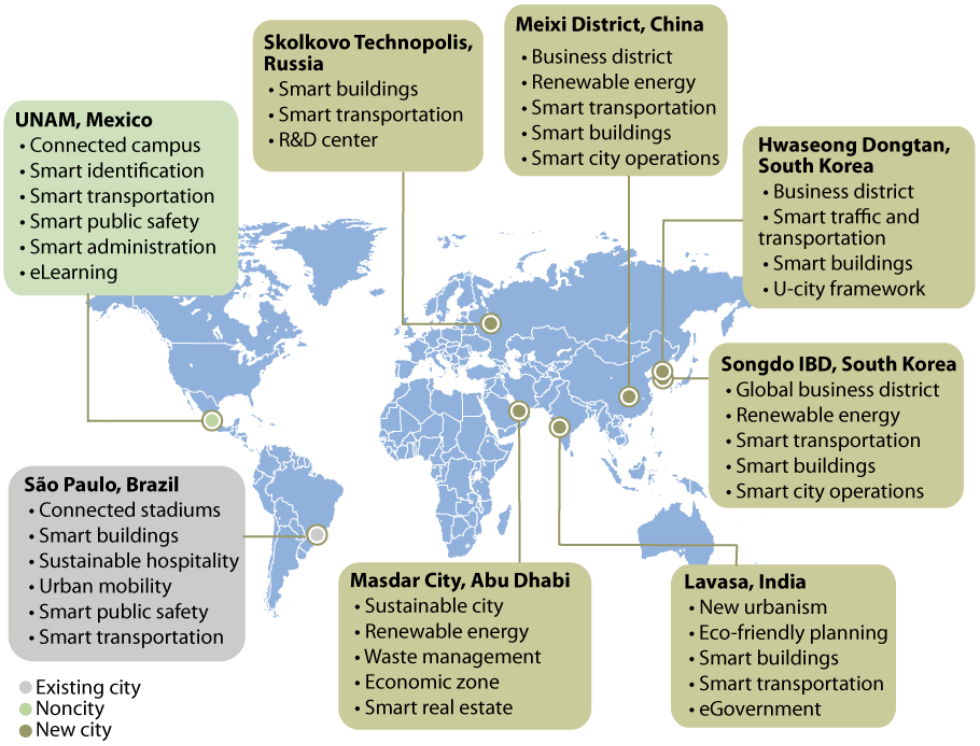
Table 14: Top 40 Global Smart Cities, 2019[40]

Rank	City	Comment
1	London	#1 – Human Capital, #3 – Transportation (behind Shanghai and Beijing – outside top 50), #1 – International Outreach
2	New York	#3 – Human Capital, #1 – Economy, #2 – Urban Planning
3	Amsterdam	#2 – International Outreach
4	Paris	#3 – International Outreach
5	Reykjavik	#1 – Environment
6	Tokyo	#3 – Economy
7	Singapore	#1 – Technology
8	Copenhagen	#3 – Environment
9	Berlin	
10	Vienna	
11	Hong Kong	#2 – Technology
12	Seoul	
13	Stockholm	
14	Oslo	
15	Zurich	#1 – Social Cohesion
16	Los Angeles	#2 – Human Capital, #2 – Economy
17	Chicago	
18	Sydney	
19	Melbourne	
20	San Francisco	#3 – Technology
21	Helsinki	
22	Washington D.C.	
23	Madrid	
24	Boston	
25	Wellington	#2 – Environment
26	Munich	
27	Barcelona	
28	Basel	
29	Taipei	#3 – Social Cohesion, #3 – Governance
30	Berne	#2 – Social Cohesion, #1 – Governance
31	Barcelona	
32	Geneva	#2 – Governance
33	Frankfurt	
34	Hamburg	
35	Auckland	
36	Gothenburg	
37	Dublin	
38	Montreal	
39	Ottawa	
40	Miami	

Americas Europe Asia

[40] IESE Cities in Motion Index

Figure 24: Smart City Development Examples Outside North America and Western Europe[41]



Three technology-related layers combine to create a functioning smart city:

1. **Technology base** – including a mass of cell phones and other sensors connected by a high-speed, high-capacity communications network with open data portals;
2. **Applications** – specific programs and digital tools for key functions including economic development, energy, health, housing, mobility, security, waste, water, and engagement/community; and
3. **Public usage** – applications, and the smart city as a whole, rely on broad adoption and resulting changes in citizen behaviors. Applications that provide citizens greater transparency and optimize their choices generate wide adoption.

More than 80 percent of the Latin American and Caribbean region population lives in cities; however, 27 percent of the urban population lives in informal settlements without access to basic services.[42] As a result, digitization is not yet uniformly distributed.

Nonetheless, in the Latin America and Caribbean region, numerous municipalities are already implementing smart city initiatives, and several rank among high and medium performers in the IESE Cities in Motion (Smart Cities) Index of 174 global cities:

[41] Forrester Research
[42] Inter-American Development Bank

- Santiago, Chile (66 - High);
- Buenos Aires, Argentina (77 - Medium);
- Montevideo, Uruguay (92 - Medium);
- San José, Costa. Rica (112 - Medium);
- Panama City, Panama (114 – Medium); and
- Bogotá, Colombia (117 - Medium).

Latin America and Caribbean cities considered in the IESE rankings are highlighted below in Figure 25. One Mexican City, Mexico City, is included in the IESE index.

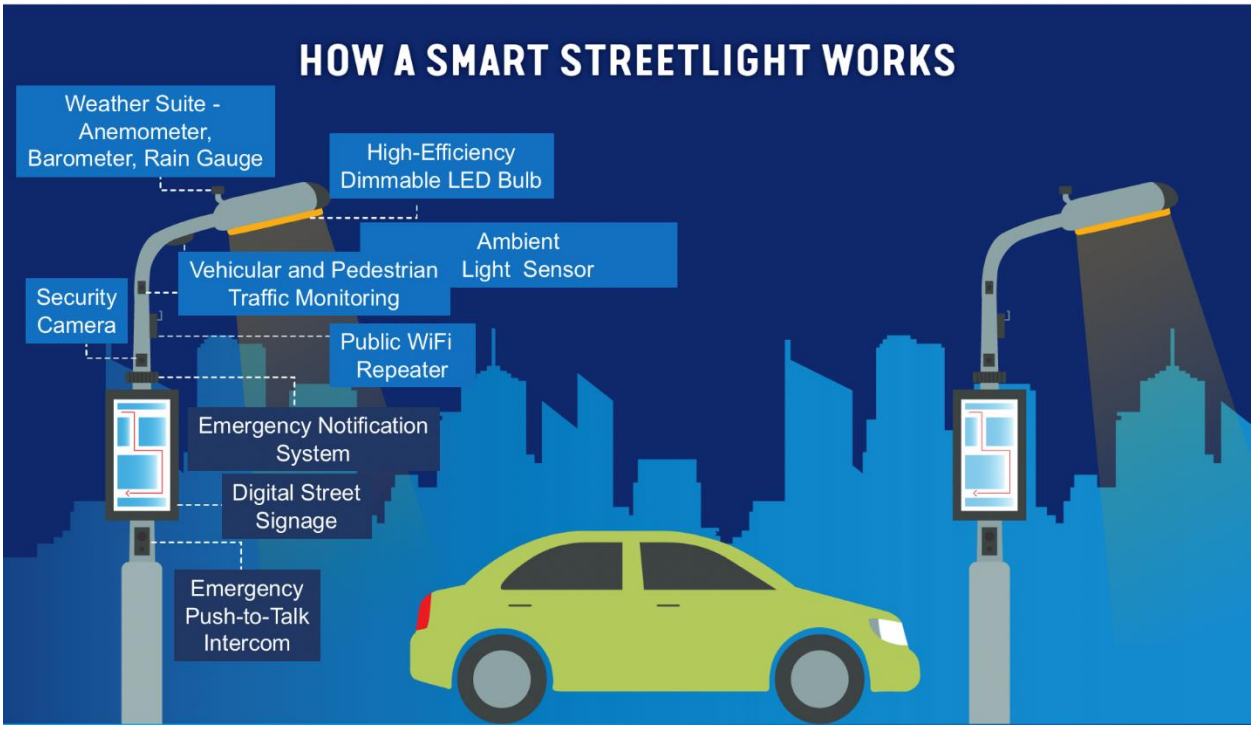
Figure 25: Latin American and Caribbean Cities in IESE Cities in Motion (Smart Cities) Index[43]

[43] IESE

A4.1.2 Smart Street Lighting

One of the early programs typically undertaken on the path toward creating a smart city is smart street lighting. Smart streetlights are networked, intelligent lighting systems consisting of smart lamp posts, LED luminaires, sensors, communication modules, and other peripheral devices. Smart streetlights improve safety, manage municipal energy consumption, and frequently provide both citizen and municipal access to warning and communication features highlighting crimes in progress, as well as impending weather events and natural disasters. Smart street lighting poles may provide public WiFi access and device charging, as shown in Figure 26.

Figure 26: Smart Street Lighting Features[44]



A4.1.3 e-Government

e-Government applies information and communications technologies, like high speed/high volume communications networks, the internet, and various apps, to enhance government activities, streamline processes, and generate citizen use and interest. These changes serve to increase government efficiency, transparency, and citizen involvement.

At the national/federal level, the Division of Public Administration and Development Management (DPAPM) of the United Nations Department of Economic and Social Affairs (UN-DESA)

[44] Coolfire Solutions

conducts a bi-annual e-Government survey including an *e-Government Development Index (EGDI)*. It is a comparative ranking of 193 countries of the world using three indicators:

1. An Online Service Index (OSI) measuring the online presence of the government in terms of service delivery;
2. A Telecommunication Infrastructure Index (TII); and
3. A Human Capital Index (HCI).

The Survey assesses the UN's 193 member states according to a quantitative composite e-Government readiness index based on website assessment, telecommunications infrastructure, and human resources capabilities. The TII, which focuses on ICT availability, considers internet access, fixed and mobile telephone subscriptions, and fixed and wireless broadband availability.

As is the case for smart cities, the top scorers in the EGDI are typically high-income countries, including the West European nations, the United States, Singapore, South Korea, Australia, and New Zealand.

Uruguay is the only Latin American country with a "very high" EGDI score (34th globally), though Chile, Argentina, and Brazil fall just shy of this level, as shown in Table 15. Mexico ranks eighth in the Americas. As a whole, Latin America and the Caribbean showed the largest regional improvement globally between the UN's 2016 and 2018 surveys. Across the Americas, the United States stands at 11th globally, with Canada ranking as 23rd.

Table 15: The United Nations EGDI Top Ten Americas Countries in e-Government[45]

2018 Americas Rank	Country	EGDI	EGDI Group	2020 Global Rank
1	United States of America	0.8769	VH	9
2	Uruguay	0.7858	V3	26
3	Canada	0.8258	V3	28
4	Argentina	0.7335	V2	32
5	Chile	0.7350	V2	34
6	Brazil	0.7327	V1	54
7	Costa Rica	0.7004	V1	56
8	Mexico	0.6818	HV	61
9	Barbados	0.7229	HV	62
10	Colombia	0.6871	HV	67

A4.1.3 Payment Systems

Digital payment systems are used by all government levels (national, state, and municipal) to increase revenue collection, exceed constituent expectations, and improve cash flow. Not only do

[45] United Nations

these ICT systems improve payment and collections efficiency and accuracy in normal times, but during the COVID-19 global pandemic, they allowed citizens to access government services while in quarantine or social distancing. Contactless digital payments at the point of collection, powered by facial recognition, Quick Response (QR) codes, or near-field communications (NFC), can make it less likely for the virus to spread to others through cash exchanges. Online payments have helped to put government stimulus funds into consumers' hands more rapidly across the globe.

In the Latin American and Caribbean region overall, while online identification and authentication systems are fairly robust, several challenges exist to broader deployment of digital financial systems (DFS):[46]

- Boosting financial inclusion across populations regardless of income levels and geographic location;
- The ability of regulatory agencies to respond to evolving DFS deployment;
- Infrastructure development;
- Management of the rural/urban population divide; and
- Population readiness in areas where digital literacy is low and trust is high in cash-based transactions.

In terms of usage levels, e-commerce and the DFS ecosystem still reach a relatively small portion of the population in the Andean countries covered in this Resource Guide, and digital wallets today are a small market niche. Limited levels of physical infrastructure, needed regulatory reforms, and the high percentage of people outside the formal labor market remain barriers to the more widespread adoption of DFS. In many markets, there are disconnects between comparatively high levels of smartphone ownership and low levels of m-commerce and between increasingly mature identification and authentication systems and remaining issues with security and safety. Nonetheless, the region is showing strong evidence of innovation and adoption.

A4.2 Smart Cities and e-Government - Investment Outlook

The global Smart Cities business opportunity is estimated at $2 trillion by 2025[47], with the Latin American/Caribbean region representing roughly 10 percent of the total. Growth will arise from a global base of about $1 trillion today, although estimates vary widely. The anticipated compound annual growth (CAGR) is 15 percent. The development of Latin American/Caribbean smart cities currently lags behind other regions such as Asia, North America, and Europe, but numerous programs are either in process or planned. Estimates suggest that globally, the public sector has around 70 percent ownership of smart-cities applications, with 60 percent of the required initial investment arising from the private sector.[48] In addition to the bricks and mortar and associated services required for developing new buildings and housing developments, a wide range of ICTs will be critical to smart city development and e-Government, including:

- 5G and other telecommunications infrastructure and services;
- Voice assistants;

[46] AFI Global https://www.afi-global.org/sites/default/files/publications/2019-07/AFI_FILAC_SP_AW_digital.pdf
[47] Frost & Sullivan
[48] McKinsey and Company

- Artificial Intelligence (AI);
- Internet of Things (IoT);
- Building automation;
- Sensors;
- Big data;
- Cloud computing;
- Cleantech;
- Distributed energy generation;
- Cybersecurity;
- Surveillance;
- Electric and autonomous vehicles (EV and AV) sensors; and
- Advanced driver assistance systems (ADAS).

The global ICT investment in e-Government was approximately $600 to 700 billion in 2019.[49] Communication and IT services represent about two-thirds of investments, while software, devices, and data centers comprise the remaining third. Big Data, the Internet of Things (IoT), and customized apps continue to be new focal points for investment technology.

A4.3 Mexico

Mexico ranks 61st globally on the United Nations e-Government Development Index (EGDI) and 41st globally in e-participation. IESE recognizes Mexico City (130th globally) as the only Mexican municipality in its Cities in Motion (Smart Cities) Index.

Nonetheless, Mexico has undertaken numerous national and state/regional e-government and smart cities initiatives. This Resource Guide profiles three current projects. The National Digital Identity System and Modernization of Public Financial Management Systems projects seek to render their associated processes more efficient and effective at the national level. At a local level, the city of Chetumal, the capital of the State of Quintana Roo, is establishing a free trade zone and smart city within a new industrial park.

[49] Grandview Research

A5 Internet of Things (IoT) and Artificial Intelligence (AI)

A5.1 Sector Overview

The Internet of Things (IoT) and Artificial Intelligence (AI) are closely related. IoT is the networking capability allowing information to be sent to and received from objects and devices (such as home appliances, industrial systems, and modes of transportation) using the Internet. AI is the capability of a machine to imitate intelligent human behavior. AI is often incorporated in IoT applications to enhance performance and better predict user needs.

A5.1.1 The Internet of Things (IoT)

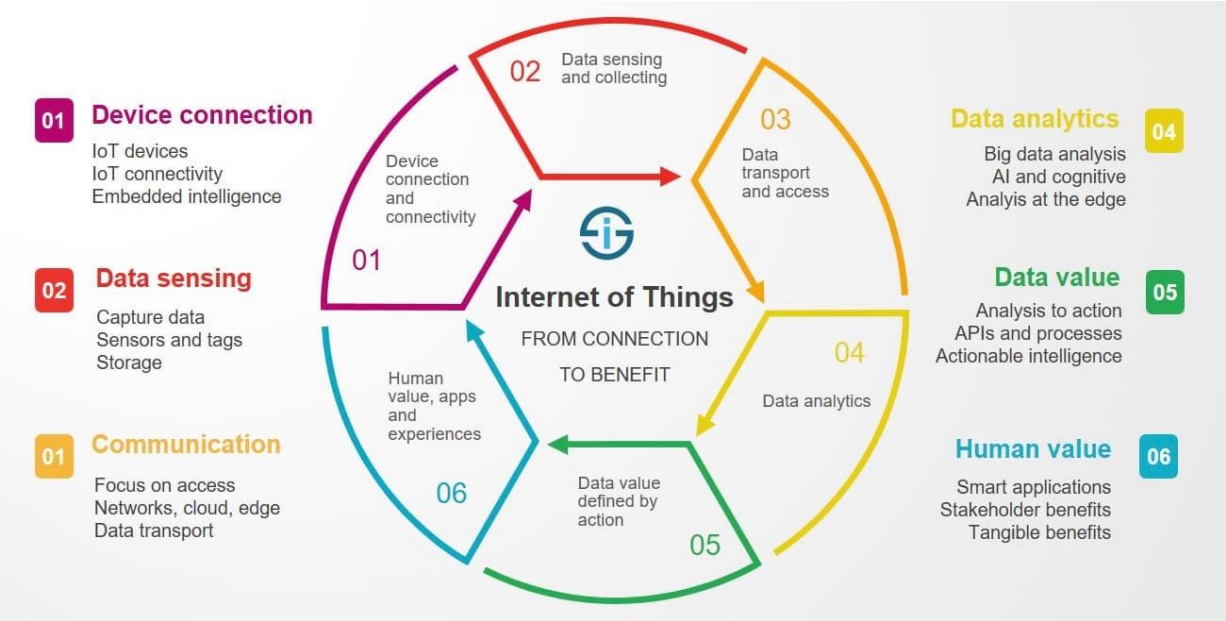
The IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals, or people provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. A *"Thing"* may be an automobile with sensors monitoring/adjusting performance systems; a person with an electronic implant such as a pacemaker; livestock/individual animals with biochip transponders; a manufacturing plant or piece of equipment with smart sensors; or any other natural or human-made object which may be assigned an Internet Protocol (IP) address and can transfer data over a network.

IoT ecosystems comprise web-capable smart devices using embedded processors, sensors, cameras, and communication hardware to collect, send, and act on data acquired from their environments. IoT devices share the sensor data collected by connecting to an IoT gateway or other edge device and send it to the cloud for processing (or sometimes local analysis). IoT devices generally operate without human intervention. However, humans do interact with the devices for setup, instruction, and access to information resulting from machine data analysis, as shown in Figure 27. IoT devices frequently communicate with other related devices and act on the information obtained from one another. IoT devices can also use artificial intelligence (AI) and machine learning to make data collection and analysis processes easier and more dynamic.

IoT benefits include:

- Access to information from anywhere at any time on any device;
- Improved communication among connected devices; and
- Task automation, improving business, consumer, and production process efficiency, while also reducing human intervention and required labor.

Figure 27: Internet of Things (IoT) Data and Benefit Cycle [50]



Challenges to wide IoT adoption include:

- The need for a uniform international standard of compatibility for IoT, lack of which currently limits the abilities of devices from different manufacturers and regions to communicate with each other;
- The ability of enterprises to manage with massive numbers of interconnected IoT devices (up to and. including in the millions) and the associated challenges in collecting and managing extensive quantities of data;
- The possibility all interconnected devices will become corrupted if a bug manifests in one; and
- The potential is that hackers may steal confidential information, particularly as the number of connected devices increases and more information is shared among devices.

IoT uses span numerous markets and applications, including but not limited to:

- Home (security, appliances, automation);
- Industrial and utilities (process control, machine-to-machine automation, logistics);
- Transportation (aircraft, railroad and light rail, vehicular);
- Agriculture (soil and crop management, livestock care);
- Government and military (smart cities, aerospace and defense, and e-Government);
- Healthcare (telemedicine, predictive diagnostics, robotic and image-guided surgery);
- Environmental (weather and climate management and prediction, fire and flood detection, wildlife management);
- Retail (logistics, inventory control, security); and

[50] I-Scoop.eu

- Building and construction (fault prediction, energy management, and heavy machinery control).

Today, in the Latin American/Caribbean region, Brazil hosts just under half of regional IoT devices, with Mexico and Colombia representing the next two largest users. The rest of Latin America and the Caribbean, in total, comprises 20 to 25 percent of current IoT device usage.

A5.1.2 Artificial Intelligence

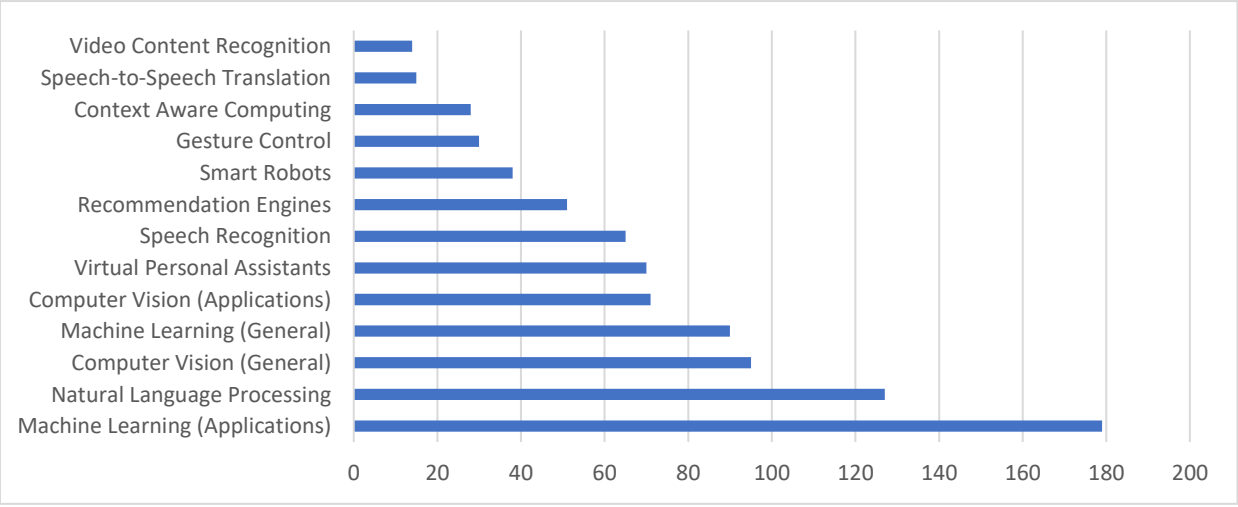
Artificial Intelligence (AI) is the simulation of human cognitive capabilities in machines programmed to think and mimic the actions of people. Any machine exhibiting traits associated with a human mind, such as learning and problem-solving, may be described as using artificial intelligence. The key characteristic of AI is its ability to rationalize and take actions having an optimized chance of achieving a specific goal.

Artificial intelligence divides into two categories:

- **Weak:** a system designed to carry out one particular job (e.g., playing chess or personal assistants such as Amazon's Alexa or Apple's Siri where the assistant is asked a question and answers it); and
- **Strong:** typically complex systems performing multiple tasks considered human-like, programmed to handle situations requiring problem solutions without human intervention. (e.g., self-driving cars or robotic and image-guided surgery).

AI technologies are evolving rapidly. Over 800 companies are developing AI technologies and solutions spanning: machine learning; computer visioning; language processing, recognition and translation; and movement and context recognition and interpretation, as described in Figure 28.

Figure 28: Artificial Intelligence Innovation Areas, 2020 (Number of Companies Developing Solutions)[51]



[51] Venture Scanner

AI solutions offer benefits including:

- Labor and home/personal management cost reduction;
- Worker safety (e.g., allowing machines to replace humans in risky environments);
- Ability to perform tasks more quickly and effectively than the average human (e.g., reading digital medical images and performing complex surgeries); and
- Scalability and 24/7/365 service availability and access from any location.

A challenge facing AI is the concern about the potential replacement of human labor by machines, leading to possible unemployment. Another concern is that machines may become so highly developed that humans will not be able to keep up with machine learning, creating a prospect that machines could evolve themselves to take over society. Yet another is that AI devices may have the ability to hack into human privacy or be weaponized. Many debate the ethics of artificial intelligence and how intelligent systems should be treated legally vis-à-vis human rights.

For the Latin America and Caribbean region, which has historically lagged larger economy regions in worker productivity, AI offers an opportunity to leapfrog to greater innovation and economic progress. Research suggests AI can add a full percentage of GDP to five of South America's largest economies (Argentina, Brazil, Chile, Colombia, and Peru) by 2035.[52] By year-end 2019, 79 percent of Latin American companies had launched AI initiatives, with fewer than two percent reporting lower than expected investment returns.[53]

A5.1.3 Digital Payment Systems

Electronic payments allow customers to pay for products or services online. An e-commerce payment system facilitates transactions seamlessly among several parties:

- The account holder, or consumer**,** who purchases a product or service online;
- The merchant who sells goods and services to the consumer;
- The issuer (the financial institution providing the consumer with a payment account or card);
- The acquirer (the merchant account provider, the financial institution that establishes an account with the merchant). The acquirer authorizes the legitimacy of the consumer account;
- The payments processor, who handles the official transaction between the consumer and the merchant; and
- The payment gateway (processes merchant payment messages and uses security protocols and encryptions to ensure transaction safety).

Artificial Intelligence is gaining momentum in the digital payments market, both in backend operations and customer-facing payment systems. AI digital payment applications include:

[52] Inter-American Development Bank
[53] Massachusetts Institute of Technology (MIT)

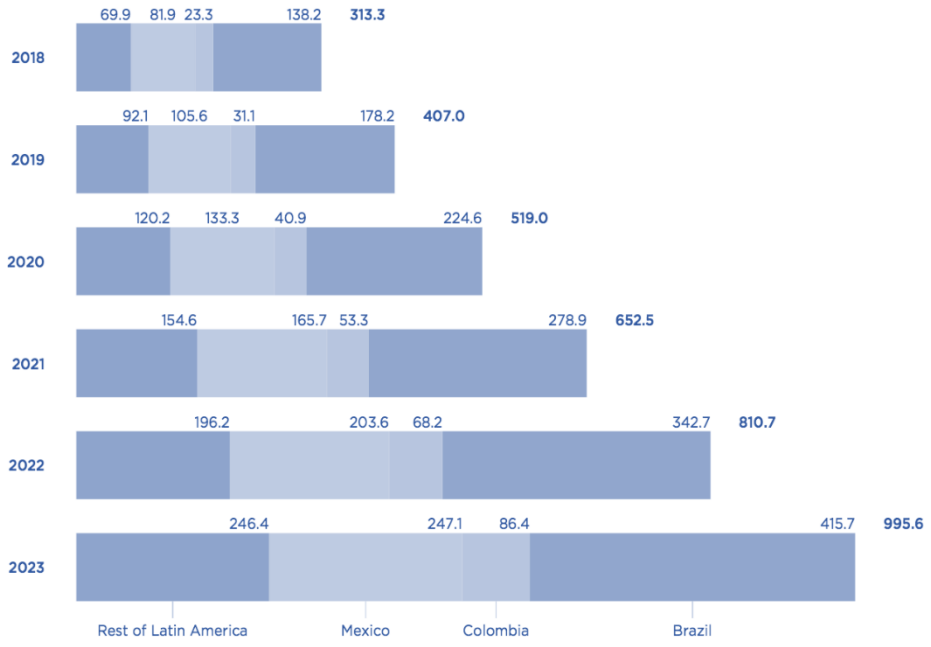
- Fraud protection facial recognition;
- Smarter Stan-In Processing (Smarter STIP) and other technologies to ensure fast interruption-free transaction; and
- Fraud-resilient settlement technology with transaction pattern recognition, human error reduction, and AI-enhanced cybersecurity.

A5.2 Internet of Things (IoT) and Artificial Intelligence (AI) Investment Outlook

In 2019, the global market for IoT was approximately $745 billion.[54] By 2025, projections suggest 41.6 billion IoT devices will be connected globally, generating 79.4 zettabytes of data. Global spending will exceed $1 trillion by 2022.[55]

In 2017, the Latin American/Caribbean region hosted 400 million connected devices. By 2023, MIT forecasts that the number will reach over one billion connected IoT devices. The region will represent the fastest growth in IoT spending through 2025. While Brazil is and will remain the largest IoT device consumer, Mexico (28.3 percent compound annual growth rate (CAGR)), Colombia (24.9 percent CAGR), and Chile (23.3 percent CAGR) are projected to lead growth in the region, as shown in Figure 29.

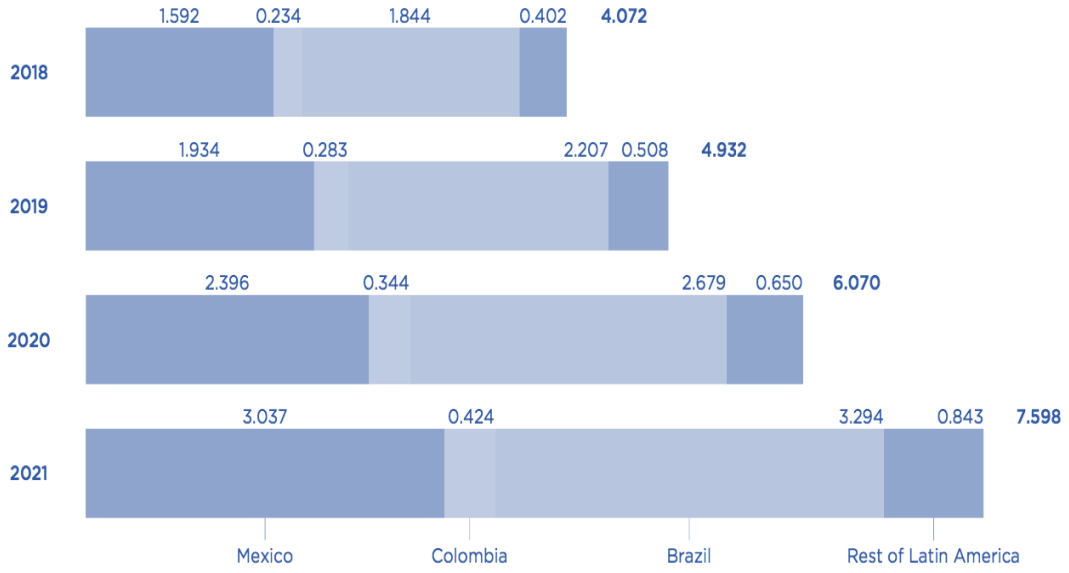
Figure 29: Latin America and Caribbean Internet of Things (IoT) Device Forecast, 2018-2023 (million units)[56]



[54] Ibid
[55] Ibid
[56] Ibid

The foregoing device numbers translate to a regional market of almost $5 billion in 2019. The Latin American/Caribbean region IoT market will grow to $7.6 billion by 2022, or at a compound annual growth rate of above 20 percent, as shown in Figure 30.

Figure 30: Latin American and Caribbean Internet of Things (IoT) Revenue Forecast, 2018-2023 ($ billion)[57]



Although the Latin America and the Caribbean AI market was relatively small (various estimates suggested under $1 billion in 2019), the region is already seeing substantial economic benefits from artificial intelligence. Several factors will drive growth, with big data providing traction and image processing being a critical application area. The large amount of data required to train AI systems for character and image recognition has, to date, constrained growth. Visa, for example, reported that artificial intelligence allowed regional financial institutions to avoid $2 billion in credit card fraud in 2019 on a payment volume of $430 billion.

A5.3 Mexico

Mexican industrial IoT market revenues will reach close to four billion dollars by 2022, demonstrating growth at a compound annual rate of over 23 percent since 2016.[58] Growth drivers include migrating from Internet Protocol Version 4 (IPv4) to IPv6 and from 4G/LTE to 5G to provide future addresses and bandwidth for IoT. 5G should increase network capacity by almost an order of magnitude, with data speeds greater than 1 Gbps and near-zero latency. IPv6, the latest Internet Protocol, can assign 100 unique IP addresses to every atom on the surface of the earth. Further, average selling prices for sensors should decline, with industry analysts suggesting prices will fall at twice the rate of the last five years. The Mexican industrial IoT market ecosystem

[57] Inter-American Development Bank
[58] Frost & Sullivan https://store.frost.com/mexican-industrial-internet-of-things-market-forecast-to-2022.html

includes vendors, integrators, and service providers offering IoT wireless and fixed two-way communication technologies.

The growth in Mexican data center capacity will support further penetration of AI technologies. The COVID-19 global pandemic allowed Mexican companies to acutely realize the importance of adopting technologies like AI to digitize, improve the quality of customer service, and enhance cooperation with employees and commercial partners while also reducing costs and increasing income. As shown in Figure 31, the Dell Technology Digital Transformation Index[59] suggests 52 percent of the Mexican companies surveyed considered themselves "digital adopters," well ahead of world levels. While only 6 percent (comparable to world levels) today view themselves as digital leaders, the index suggests a readiness for strong future growth in AI.

Figure 31: Mexico versus World Corporate Digital Technology Index

Mexico has undertaken a variety of IoT and AI implementations through its various smart cities efforts and in the private sector. As profiled in this Resource Guide, Mexican-based, global cement supplier CEMEX is moving into the second phase of smart-process and customer automation under its Digital Transformations 4.0 project. Further, the Queretaro Digital Hub smart cities project also incorporates IoT and AI features.

[59] Dell Technologies https://www.delltechnologies.com/es-mx/perspectives/digital-transformation-index.htm

Annex B: List of Acronyms

ACRONYM	DEFINITION
3D	Three Dimensional
2G	Second Generation Cellular Network
2N	Completely Redundant
3G	Third Generation Cellular Network
4G	Fourth Generation Cellular Network
4.5G	Fourth and One-Half Generation Cellular Network
5G	Fifth Generation Cellular Network
6G	Sixth Generation Cellular Network
aaS	As a Service
ADAS	Advanced Driver Assistance Systems
AI	Artificial Intelligence
AMPS	Advanced Mobile Phone Service
AV	Autonomous Vehicle
BaaS	Backend as a Service
BPL	Broadband over Powerlines
C-RAN	Centralized Radio Access Network
CAGR	Compound Annual Growth Rate
CARICOM	Caribbean Community
CDMA	Code Division Multiple Access
CEDN	Coordinación de Estratégia Digital Nacional
CEMEX	CEMEX S.A.B. de C.V.
Ceprodi 4.0	Regional Productivity Center 4.0
CFE	Comisión Federal de Electricidad
CFE TEIT	CFE Telecomunicaciones Internet para Todos
CID	Digital Inclusion Center
Cidesi	Center for Engineering and Industrial Development
CINVESTAV	Center for Advanced Technology, the Center for Research and Advanced Studies
CLEMA	Consortium for Applied Research, Innovation and Training of High-Level Human Resources in Logistics Distribution, Energy, and Advanced Manufacturing
CONCAMIN	Confederation of Industrial Chambers of Mexico
ConMad	3D Printing Consortium
CURP	Unique Population Registry Code

CX 4.0 Operations	Industry 4.0 Technologies
DFS	Digital Financing Systems
DGPTR	Dirección General de Política de Telecomunicaciones y Radiodifusión
DIGIFAB	Digital Manufacturing Laboratory
DPAPM	Division of Public Administration and Development Management
DSL	Digital Subscriber Line
EDGE	Enhanced Data Rates for GSM Technology
EGDI	e-Government Development Index
EPC	Engineering, Procurement, and Construction
EV	Electric Vehicle
EVDO	Evolution Data Optimized
FOCIR	Fondo de Capitalización e Inversión del Sector Rural
FTTH	Fiber to the House
GDP	Gross Domestic Product
GE	General Electric
GHz	Gigahertz
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HCI	Human Capital Index
HSPA	High-Speed Packet Access
HVAC	Heating Ventilation and Air Conditioning
IaaS	Infrastructure as a Service
IADB	Inter-American Development Bank
IBRD	International Bank for Reconstruction and Development, World Bank Group
IBRD	International Bank for Redevelopment
ICT	Information and Communication Technology
ID	Identification
IDP	Identity Provider
IESE	Graduate Business School of the University of Navarra, Barcelona, Spain
IFT	Instituto Federal de Telecomunicaciones
IoT	Internet of Things
IP	Internet Protocol
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
IS	Information Systems
IT	Information Technology
Kbps	Kilobits per Second

km	Kilometer
LAC	Latin America and the Caribbean
LaTeC2	Laboratorio de Técnicas Cuánticas para las Comunicaciones
LCMSSCS	Lázaro Cárdenas-Manzanillo Santiago Submarine Cable System
LED	Light-Emitting Diode
LEO	Low Earth Orbit
LLC	Limited Liability Corporation
LTE	Long-Term Evolution
M²	Square Meters
Mbps	Millions of Bits per Second
MIMO	Multiple-Input/Multiple-Output
MIT	Massachusetts Institute of Technology
MVNO	Mobile Virtual Network operator
MW	Megawatt
N+2	Two extra components (here, data center cooling)
NDS	Mexico's National Digital Strategy
NFC	Near-Field Communications
NJ	New Jersey
NMT	Nordic Mobile Telephony
NOMA	Non-Orthogonal Multiple Access
NTT	Nippon Telephone and Telegraph
NYC	New York City
OMA	Orthogonal Multiple Access
OSI	Online Service Index
OTT	Over-The-Top
PaaS	Platform as a Service
PAC	Pan American Crossing
PEDETI	Programa Estatal para el Desarrollo de Tecnología e Innovación
PFM	Public Financial Management
PPP	Public Private Partnership
PROMTEL	Organismo Promoter de Inversiones en Telecomunicaciones
QR	Quick Response
RA	Registration Agencies
RENAPO	National Population Registry
RFE	Recinto Fiscalizado Especial (Free Trade Zone)
RMC	Ready-Mixed Concrete
RNEI	Mexico's National Research and Education Network
RTT	Real-Time Text

SaaS	Software as a Service
SCT	Secretariat of Communications and Transportation
SD-WAN	Software-Defined Wide Area Network
SDM	Spatial Digital Multiplexing
SEDESU	Secretaría de Desarrollo Sostenible, Estado de Querétaro
SEGOB	Secretaría de Gobernación
SHCP	Secretaría de Hacienda y Crédito Público
SID	Registration and Identity System
Smarter STIP	Smarter Stan-In Processing
SME	Small and Medium Enterprise
SNIP	National Personal Identification Service
T&B	Telecommunications and Broadcasting
TACS	Total Access Communication System
TB	Terabyte
Tbps	Terabytes per Second
TDMA	Time Division Multiple Access
Telecomm	Telecomunicaciones de México
TII	Telecommunication Infrastructure Index
TV	Television
TX	Texas
UA	User Agency
UAQ	Autonomous University of Querétaro
UIDs	Unique Identifiers
UCLA	University of California at Los Angeles
UMTS	Universal Mobile Telecommunications System
UN	United Nations
UN-DESA	United Nations Department of Economic and Social Affairs
UNAQ	Aeronautical University of Querétaro
UPS	Uninterruptible Power Supply
UPSRJ	Polytechnic University of Santa Rosa Jáuregui
US	United States
USD	United States Dollar
USTDA	United States Trade and Development Agency
UTC	Technological University of Corregidora
UTEQ	Technological University of Querétaro
UTSJR	Technological University of San Juan Del Río
WAN	Wide Area Network
WiFi	Wireless Fidelity

WiMAX	Worldwide Interoperability for Microwave Access